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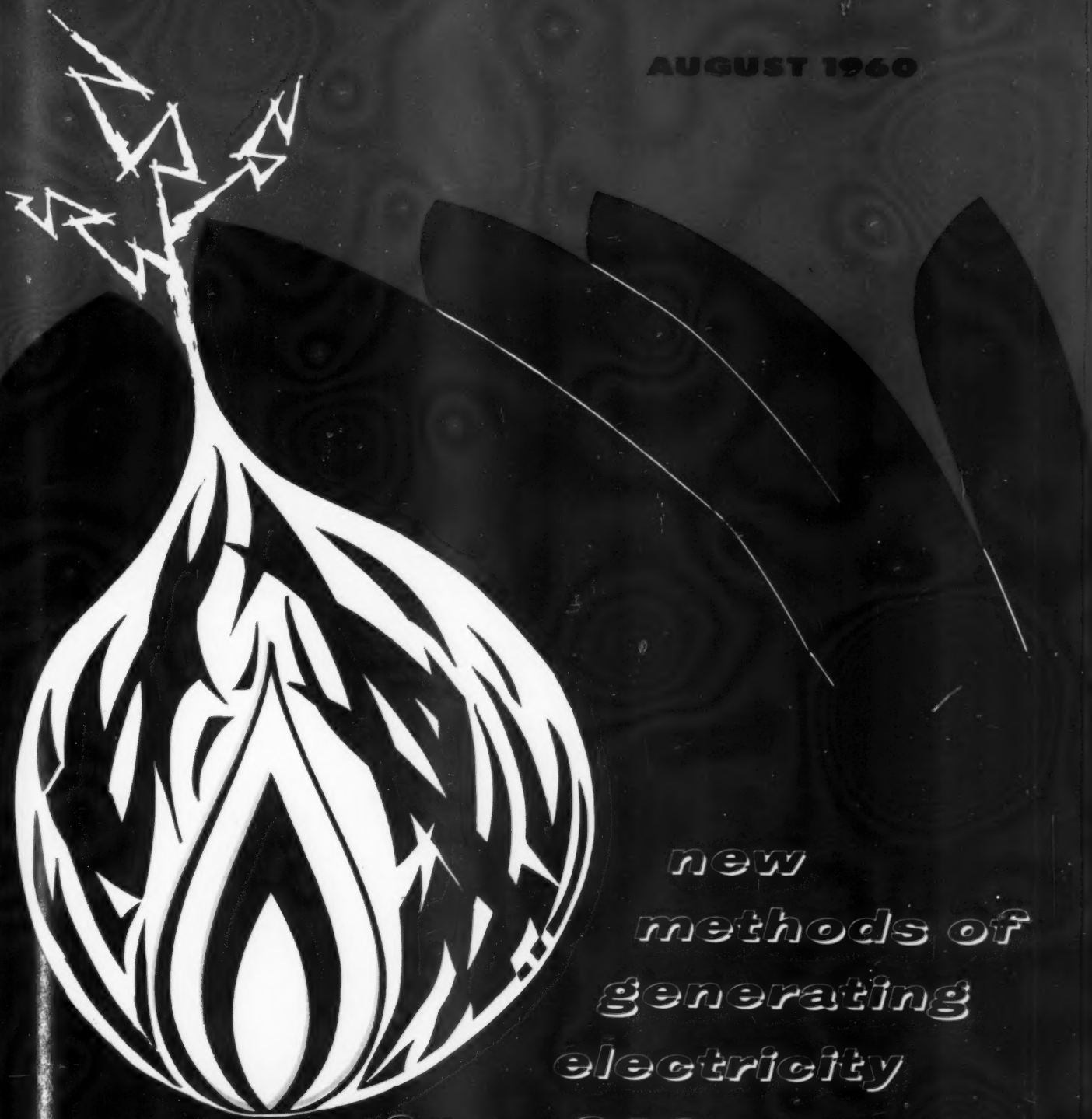
American
Gas Journal
THE MAGAZINE OF GAS DISTRIBUTION

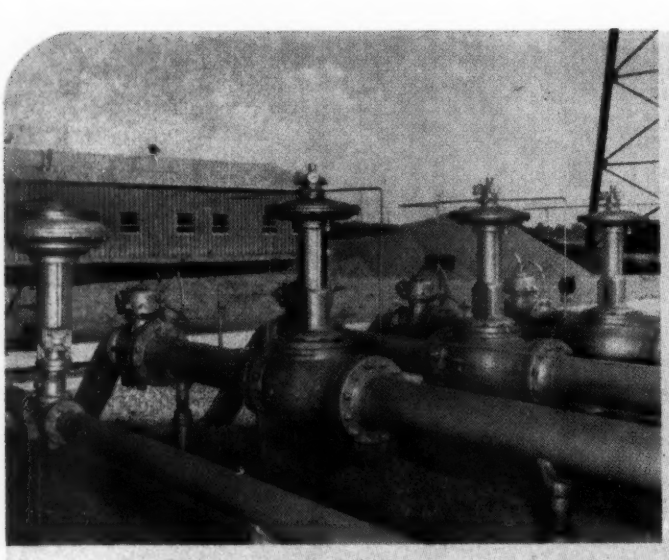
AUGUST 1960

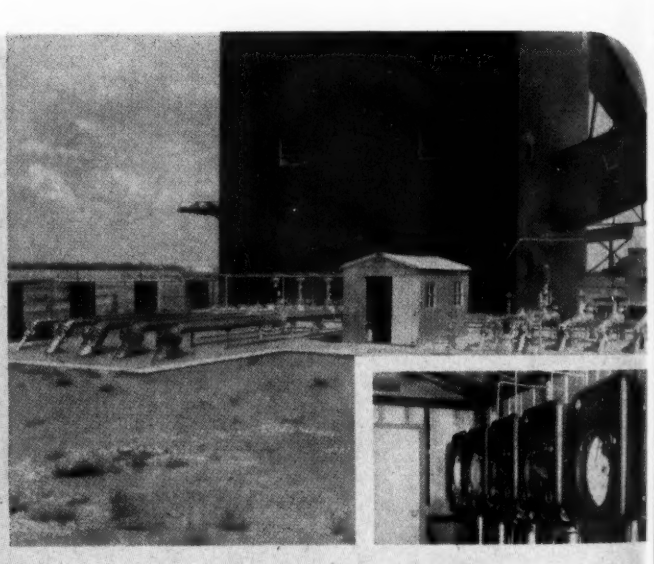


new methods of generating electricity from GAS sources

HIGH OR LOW

Positive Control with Wide Changes in Flow





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This Reliance regulator installation is designed to handle an exceptionally wide change in gas flow rates. The 250 psi inlet pressure is reduced to 35 psi by a 2-inch Type "P" regulator and three 8-inch Type "CBVA" motor valves installed in parallel. All regulators are equipped with valve positioners and are controlled by 0-100 psi American Pressure Controllers. Each line is cut in as the load is increased.

Here, at one of the nation's ten largest power plants, five meter runs are equipped to handle extreme variations in gas flow rates – from a minimum load of 40,000 to a maximum of 12,000,000 cfh. American Series A-88 Double Integrating Orifice Meters measure all gas used. These instruments (inset) provide an accurate record of the gas delivered to the power plant.

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PILOT.. ..LIGHTS

In Our Hands . . .

Significantly, this month's cover dramatizes a potential achievement of the gas industry . . . mastery of the many means of converting heat and/or chemical energy directly to electricity. The role that the gas industry plays today in furthering development of these exotic processes just might help determine the role that our industry will have in the future in supplying the nation's ever-growing energy needs.

That there will ultimately be a trend to direct conversion methods in electrical generation seems inevitable. One important incentive is greater efficiency. Another is the possibility of self-contained units — the little black boxes — that could be sized to serve individual homes or businesses. If these "black boxes" could be gas-fueled, imagine the load possibilities! Equally intriguing, and perhaps attainable sooner, are the home-conditioning (heating and cooling) units employing gas-fueled thermoelectric devices.

You can find out what's going on in the world of thermoelectrics, thermionics, and magnetohydrodynamics (gasp) by turning to page 12 for the first of two parts of a special report prepared especially for gas men.

Bigger and Better

Subscribers to the "oldest book with the newest look" in the gas industry will receive their big annual bonus in mid-August . . . the 1960 edition of *American Gas Journal's* GAS HANDBOOK ISSUE. A vast amount of new data has been added to the "bible of the industry" and many revisions made to keep the HANDBOOK current and timely. Every regular AGJ subscriber receives the HANDBOOK at no extra cost . . . and it's not sold separately.

American Gas Journal

ONLY MAGAZINE EDITED EXCLUSIVELY FOR THE GAS DISTRIBUTION INDUSTRY

Volume 187 August 1960 Number 8

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M C F

NEWS HILITES OF THE INDUSTRY

FPC can't regulate direct industrial sales, but it does have jurisdiction over the "transportation" of gas for direct sales. Asserting this authority, the commission has denied an application by South Georgia Natural Gas involving the sale of gas to the City of Thomasville, Georgia, for use in its electric generating plant. The FPC, while having no jurisdiction of direct sales, noted that it does have the responsibility to require a pipeline to show that the rate at which it proposes to make a direct sale is "at or above" a "compensatory" level — to insure that the sale will recoup a proper proportion of system costs. In this case, South Georgia proposed to sell gas to Thomasville for 34.5 cents per Mcf. The Georgia city had bought gas from South Georgia from 1955 to June 1958 for its power plant at 32 cents per Mcf. Then the rate jumped from 32 cents to 36 cents per Mcf and the city decided to convert to coal. Later, the city and South Georgia agreed upon the 34.5-cent rate. The pipeline said the sale was properly initiated under its original FPC certificate. The commission disagreed, and subsequently denied the service as not in the public convenience and necessity.

Contracts in the gas business have a way of turning out valueless, particularly when the courts begin interpreting them. In Washington, a U. S. Court of Appeals has ruled that Panhandle Eastern Pipe Line Company may continue, temporarily, to sell natural gas supplies to its own customers even when the gas technically belongs to a competitor. Involved is 127,000,000 cu ft daily of gas that Panhandle had delivered (until last fall) to Michigan Consolidated Gas Company for resale in the Detroit area. Mich Con had asked the court to order Panhandle to resume delivering the gas to Mich Con. Meanwhile, the feud between the two gas firms has broken out again in the Detroit area. Panhandle has offered to sell interruptible gas to Ford Motor Company at 35 cents per Mcf. Ford currently buys from Mich Con about 4.5-billion cu ft per year at 42.2 cents per Mcf for interruptible gas and 58.3 cents per Mcf for firm gas. In a letter to its residential gas customers, Mich Con noted that such a sale — by Panhandle to Ford — would mean an extra $5.50 cost per year from the gas-using home owners in Dearborn, Ford's headquarters.

Richfield Oil Corporation, says the California Supreme Court, is not a public utility with regard to its natural gas operations, especially the sale of gas to Southern California Edison Company for use as boiler fuel. The ruling upsets the contention of the state's Public Utilities Commission that such sale requires a certificate of public convenience and necessity. Richfield, said the court, had not dedicated its gas reserves or pipeline facilities to public use. Pacific Lighting Company has indicated it would seek a rehearing of the case. It objected to Richfield's direct sale.

Texas' new "severance beneficiary" tax on natural gas has been ruled unconstitutional by Texas District Court Judge Jack Roberts. The tax, expected to yield $15,000,000 per year in revenues, has a rate of 1½ percent of market value per Mcf of gas at the wellhead to be paid by the severance beneficiary who has last use of the gas. Pipeline companies filed more than 100 lawsuits challenging the law and seeking refunds of taxes paid in protest.

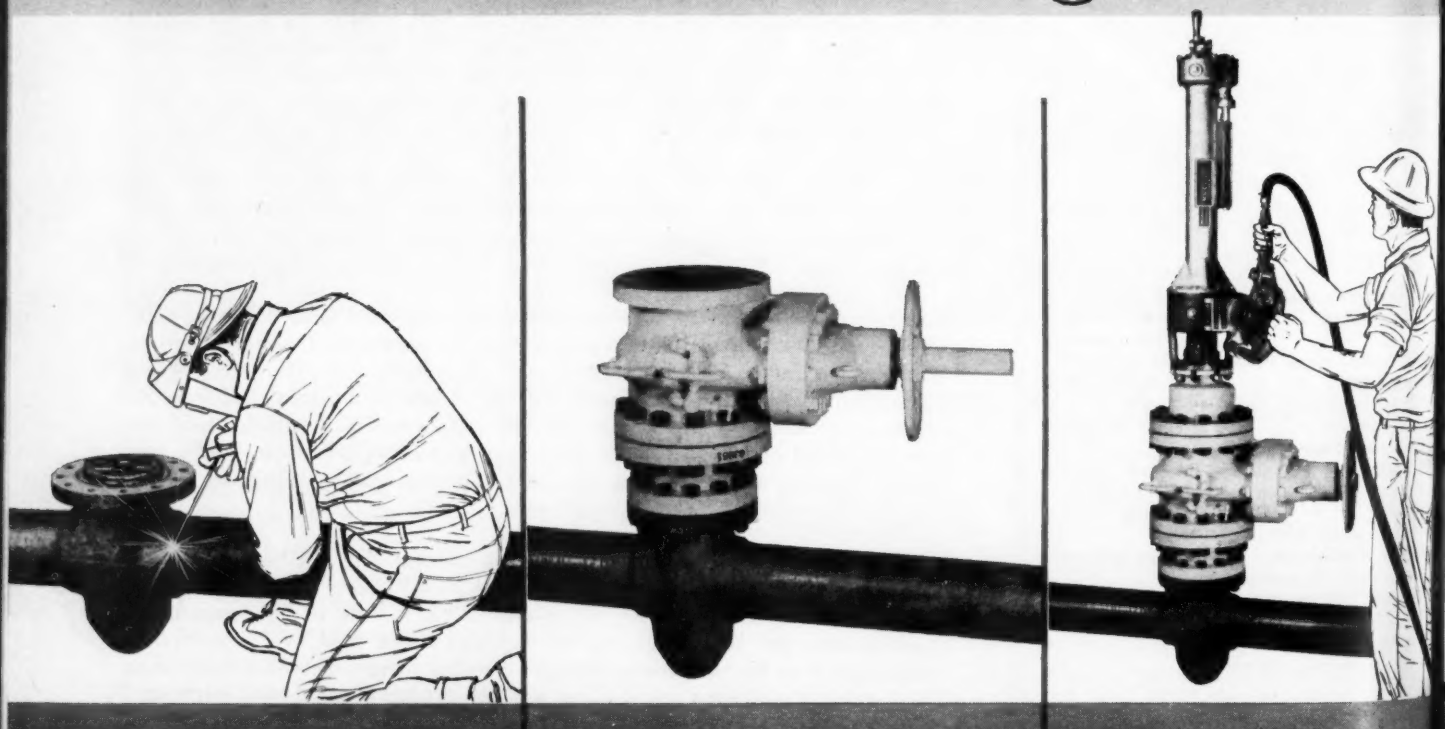
Overall rate of return of 6.52% for Southern Natural Gas Company has been allowed by the FPC. The commission said the company was allowed the rate — first pipeline company so authorized — because the FPC feels that public interest is best served by allowing a return on equity that encourages conservative financial structures. *(In the August, 1959 MCF column, page 3, AGJ reported on a prediction by the Value Line Investment Survey that the FPC would allow a 6.5% rate of return within 12 to 24 months.)*

AMERICAN GAS JOURNAL, August 1960, Vol. 187, No. 8. Published monthly except August, then semi-monthly by The Petroleum Engineer Publishing Company, P. O. Box 1589, Dallas, Texas. Second class mail privileges authorized at Dallas, Texas. Executive and Editorial Offices at 800 Davis Building, P. O. Box 1589, Dallas 21, Texas.

. . . without interrupting service

ISOLATE LINE SECTIONS *Safely*

. . . without gas blowing



STEP 1 Weld line stopper fittings to piping. Weld Save-A-Valve Drilling Nipples to piping to provide equalizing and purging connections.

STEP 2 Align special gate valves and bolt securely to line stopper fittings. Attach small gate valves to drilling nipples.

STEP 3 Bolt drilling machine to v
Cut out sections of pipe to accomm
stoppers. Close valve and remove
chine. Make cuts through drilling nip

STEP 4
alves. Co
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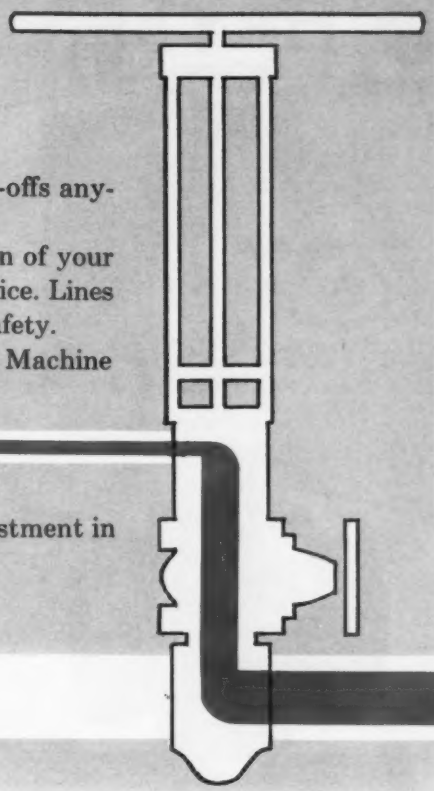
air, repla

MUELLER® NO-BLO® METHOD

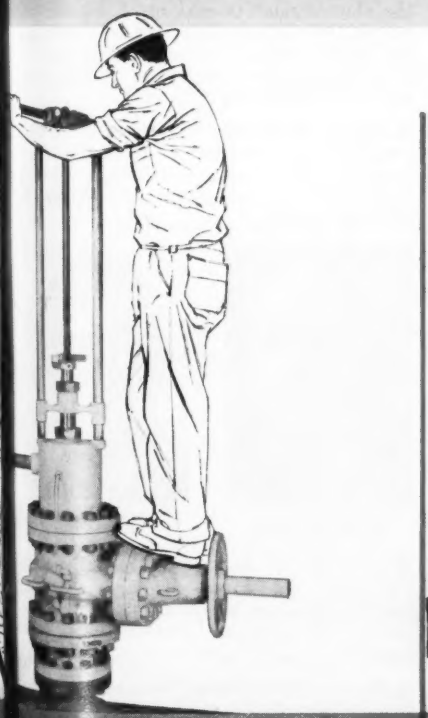


■ Here's a simple step-by-step method for making fast, effective stop-offs anywhere in your line with Mueller Line Stopper Fittings and Equipment.

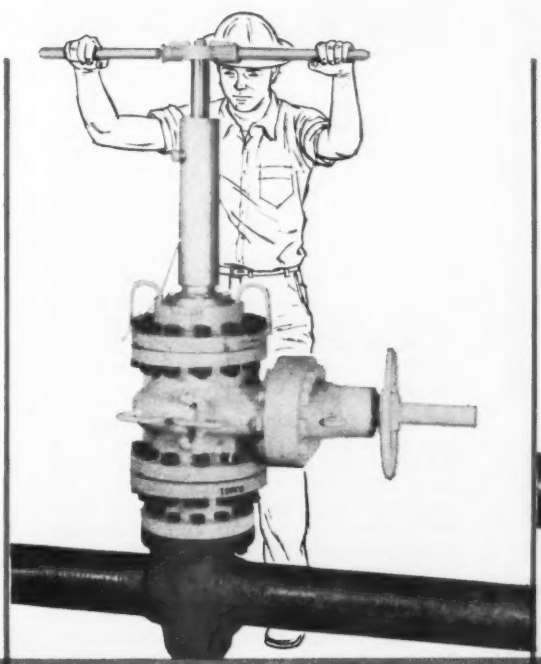
By making two such stop-offs and using a by-pass line, any section of your distribution system can be completely isolated without interrupting service. Lines and loops may be tied in, leaks repaired or fittings replaced in absolute safety.

A by-pass connection built into the body of each Mueller Stopping Machine makes it easy to install a temporary by-pass line with a minimum investment in time and materials. If desired, a separate by-pass line may be used.

Write for complete information.



STEP 4 Bolt stopping machines to valves. Connect by-pass and equalizing piping and divert flow. Make stop-offs. Section of piping now isolated for repair, replacement or tie-in.



STEP 5 Close valve and remove stopping machines and by-pass. Install completion plug in top of fittings with completion machine.

STEP 6 Remove all equipment. Bolt completion caps solidly to line stopper fittings. Cap drilling nipples.

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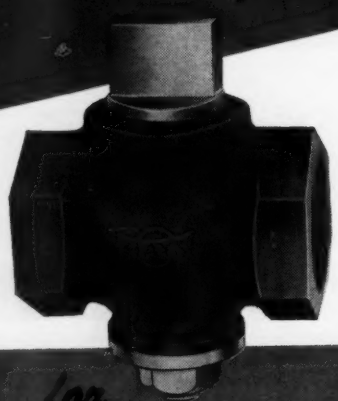

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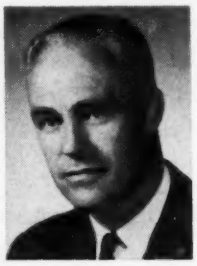
MEN AT WORK

IN THE GAS DISTRIBUTION INDUSTRY

● Northern Illinois Gas Co. has added three new vice presidents — **Mathew J. Markle,** former NI-Gas manager of operation; **William E. Preston,** former director of planning; and **C. Joseph Gauthier,** who had previously served as district manager in the south suburban area for NI-Gas.

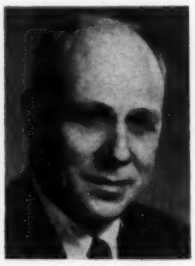
C. J. Gauthier



J. L. Tuttle

● **James L. Tuttle** has been named vice president and operating manager of the Ohio Gas Co. Previously, he was general superintendent.

F. J. Pfluke



S. F. Baldwin

● Rochester Gas and Electric Corp. has announced several personnel changes: **Harold S. Weatherby** has been elected vice president and controller; **Paul W. Briggs** has been elected secretary, and four men have been elected to the office of assistant vice presidents. They are: **George H. Fiedler,** former general superintendent of electric and steam divisions; **Frederick J. Pfluke,** former general superintendent of gas division; **Francis E. Drake Jr.,** former manager rate and economic research department, and **Schuyler F. Baldwin,** former director of public relations.

● Southern Union Gas Co., Dallas, has announced the retirement of **C. H. Zachry,** president of Southern Union since 1945. He will remain with the company as a member of the board of directors. **John H. Pritchard,** Port Arthur district manager, has also retired. He is succeeded by **Hester C. Mount,** former district sales manager in Port Arthur. **J. B. Moreland** of Austin has been named sales manager for the Port Arthur district succeeding Mount.

● Honolulu Gas Co., Ltd. has announced the appointment of **David C. Vaughan** as special assistant to the secretary-treasurer **Lowell E. Mee.**

● **Frank C. L. Sperry** and **Edgar M. Hawkins Jr.** have been elected vice presidents of Stone & Webster Service Corp. Sperry was also elected president of Conversions and Surveys, Inc., subsidiary of the Service Corp.

● **Burdette A. Johnson,** treasurer, New England Gas and Electric Association, has been elected a vice president of the Controllers Institute of America effective September 1.

● Citizens Utilities Co. has announced several executive promotions: **John C. Gibbs,** formerly vice president, operations and engineering, has been promoted to senior vice president; **Joseph E. Griffin,** former treasurer, has been promoted to vice president & treasurer, and **Ishier Jacobson,** formerly assistant vice president, has been promoted to vice president.

● **Jack D. Tolliver** has been appointed to the newly-created post of field sales manager for Tube Turns division of Chemetron Corp., Chicago. He was formerly eastern regional sales manager.

● The Grabler Manufacturing Co. has appointed **Douglass B. Williams Jr.** manager of the New York branch succeeding **Thomas P. Layer,** who has retired after 36 years of service with the company. Williams was formerly associated with Wheeling Steel Corp. as a representative in northern New Jersey.

● **R. T. Hlavin** has been named assistant sales manager for Maxitrol Co. He was formerly sales representative in the Midwest.

● **John F. Ring** has joined Ebasco Services Inc. as gas engineer in the consulting engineering department. He was formerly with Stone & Webster Service Corporation. **James F. Simes,** former manager of the planning and development department of the New Jersey Natural Gas Company has joined Ebasco Services as a general consultant to gas companies, in the management consulting division.

● **Robert B. Bradley** has been elected vice president and executive head of International Harvester Co.'s construction equipment division, succeeding **Harald T. Reishus,** retired.

R. B. Bradley

G. N. Bell

● **Gilbert N. Bell** has been appointed vice president-general manager of sales for the Sprague Meter Co. He was formerly the general sales manager for Sprague.

● **M. F. (Mike) Grace,** veteran sales representative of Robertshaw-Fulton's Grayson Controls Division, has assumed the newly-created position of product sales manager, central heating controls for the Grayson division. He will work nationally from Grayson division headquarters at Long Beach.

● **Arthur G. Baitz** has been appointed to the new post of director of engineering planning for the Robertshaw-Fulton Controls Co. Formerly he was assigned to R-F's Fulton Sylphon Division in Knoxville, Tennessee, as director of sales training. In his new capacity Baitz will coordinate development of new product lines within R-F's eight manufacturing divisions and two research centers in the U.S.

COMING EVENTS IN THE GAS DISTRIBUTION INDUSTRY

August

29-31 Appalachian Gas Measurement Short Course, University of West Virginia, Morgantown, West Virginia.

September

9 New Jersey Gas Association, annual meeting, Essex and Sussex Hotel, Spring Lake, New Jersey.

12-14 A.G.A. accident prevention conference, Leamington Hotel, Minneapolis, Minnesota.

14-16 A.G.A. Operating Section Committee on Underground Storage, Statler Hilton, Buffalo, New York.

15-16 A.G.A. Textile Processing Symposium, Sedgefield Inn, Greensboro, North Carolina.

15-17 Public Utilities Association of the Virginias, 42nd annual meeting, The Greenbrier, White Sulphur Springs, West Virginia.

18-21 ASME Petroleum Mechanical Engineering Conference, Hotel Jung, New Orleans, Louisiana.

21-23 Southeastern Gas Association, annual meeting, Sir Walter Hotel, Raleigh, North Carolina.

21-23 PCGA annual meeting, Westward Ho Hotel, Phoenix, Arizona.

26-30 ISA fall instrument-automation conference and exhibit and annual meeting, New York Coliseum, New York, New York.

27-29 Mid-West Gas Association gas school and conference, Iowa State College, Ames, Iowa.

October

3- 4 Independent Natural Gas Association of America, annual meeting, Fontainebleau Hotel, Miami Beach, Florida.

4- 5 Gas Measurement Institute, National Guard Armory, Liberal, Kansas.

5- 7 Wisconsin Utilities Association, annual gas operating and sales convention, Schroeder Hotel, Milwaukee, Wisconsin.

6- 7 NACE western regional conference, Sheraton-Palace Hotel, San Francisco, California.

6- 8 NACE, southeast region conference, Dinkler-Plaza Hotel, Atlanta, Georgia.

10-12 A.G.A. annual convention, Atlantic City, New Jersey.

11-14 NACE, northeast region conference, Pritchard Hotel, Huntington, West Virginia.

17-21 National Safety Council, annual meeting, Chicago, Illinois.

19-20 NACE north central region conference, Schroeder Hotel, Milwaukee, Wisconsin.

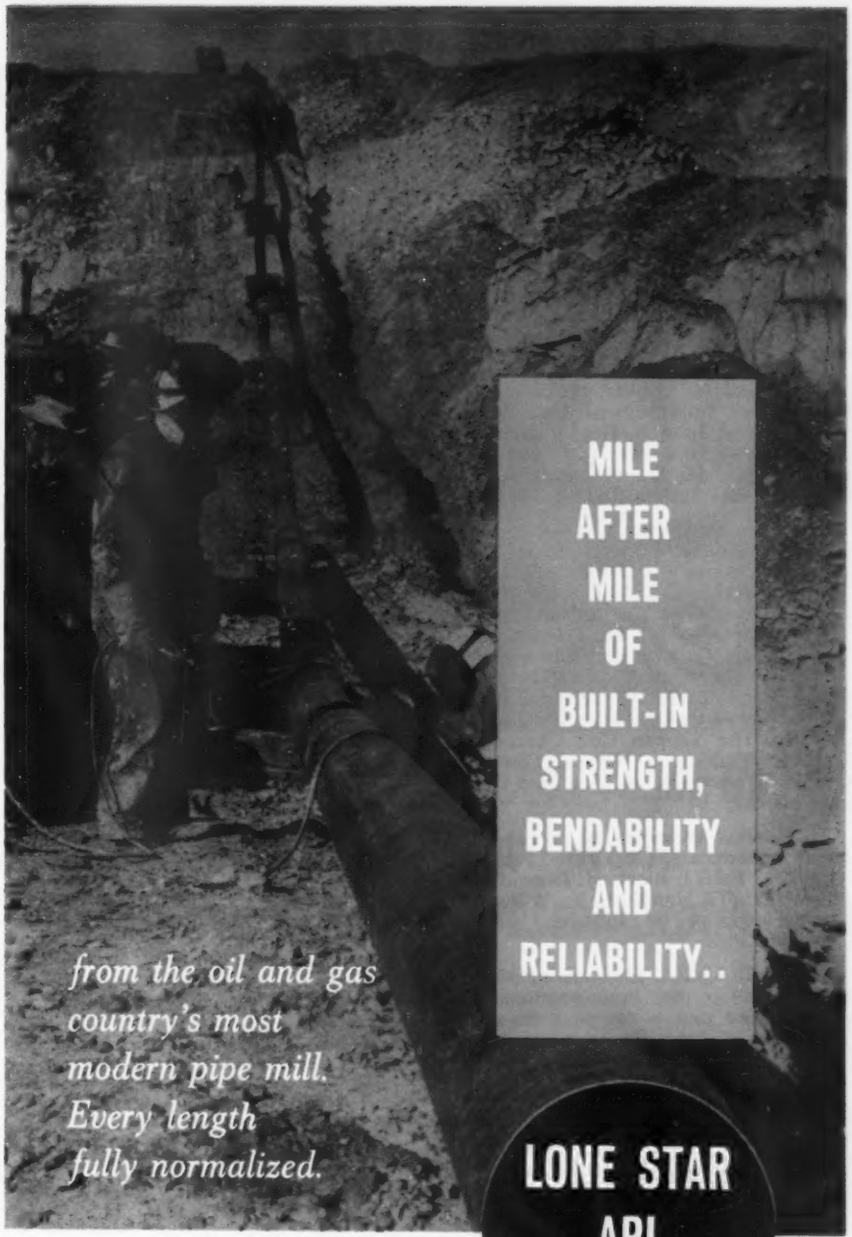
21 NEGA commercial and industrial groups, Colonial Inn, Lynnfield, Massachusetts.

23-25 Independent Petroleum Association of America, annual meeting, Statler Hilton Hotel, Dallas, Texas.

26-27 1960 Computer Applications Symposium sponsored by Armour Research Foundation of Illinois Institute of Technology, Morrison Hotel, Chicago, Illinois.

November

14-16 American Petroleum Institute, annual meeting, Chicago, Illinois.



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NEWSREEL

L. T. Potter of Lone Star Gas Co. Nominated For President of American Gas Association

Lester T. Potter, president of Lone Star Gas Co., Dallas, has been nominated for president of the American Gas Association. Elections will be held October 12 at A.G.A.'s 42nd annual convention in Atlantic City.

Other nominees are: First vice president Edward H. Smoker, president, The United Gas Improvement Co.; second vice president John E. Heyke, president, The Brooklyn Union Gas Co.; and treasurer, Charles H. Mann, treasurer, The Columbia Gas System, Inc.

Also nominated were 16 association directors. Candidates nominated for two-year terms expiring in October, 1962, are: H. Reid Derrick, Laclede Gas Co.; W. M. Elmer, Texas Gas Transmission Corp.; Roy E. Jones, North Shore Gas Co.; Otto W. Manz, Jr., Consolidated Edison Co. of New York, Inc.; Dale B. Otto, New Jersey Natural Gas Co.; R. T. Person, Public Service Co. of Colorado; Arthur B. Ritzenthaler, The Tappan Co.; Charles M. Sturkey, Washington Natural Gas Co.; Guy W. Wadsworth, Jr., Southern Counties Gas Co.

Six current members of the A.G.A. board renominated to serve two-year terms are: Eskil I. Bjork, H. Donald Borger, William G. Hamilton, Jr., William J. Harvey, Andrew W. Johnston, and E. Clyde McGraw.

Gerald T. Mullin, president of Minneapolis Gas Co., has been nominated to serve for one year to complete the unexpired term of John Heyke, nominee for second vice president.

Wister H. Ligon, president of Nashville Gas Co., automatically begins a one-year term as a member of the board upon expiration of his current term as A.G.A. president in October.

Nominees for the association's five sections are:

Accounting Section—Chairman, Reinhold H. Johnson, Brooklyn Union Gas Co., vice chairman, Conrad F. Mills, Philadelphia Electric Co.

General Management Section—Chairman, Gordon C. Griswold, Brooklyn Union Gas Co.; vice chairman, William B. Tipp, Commonwealth Services Inc.

Industrial and Commercial Gas Section — Chairman, L. J. Fretwell, Oklahoma Natural Gas Co.; vice chairman, Wilmer D. Relyea, Public Service Electric & Gas Co.

Operating Section—Chairman, Herman L. Fruechtenicht, Consumers Power Corp.; first vice chairman, Edwin F. Trunk, Laclede Gas Co.; second vice chairman, Albert B. Lauderbaugh, The Manufacturers Light & Heat Co.

Residential Gas Section — Chairman, John J. McKearin, Laclede Gas Co.; vice chairman, Frank J. McLaughlin, Providence Gas Co.

Donald S. Bittinger, president of Washington Gas Light Co., Washington, D.C., serves as chairman of the General Nominating Committee.

"King-size" gas light rules Lone Star Gas Company's collection of special promotion aids. The light was first unveiled at opening ceremonies of a new housing addition, Storybook Homes in Garland, Texas, where Mrs. America of 1960-61, Mrs. George Murphy, was present to light the huge lantern. Constructed specially for Lone Star by Hadco Aluminum Products Co. of Littletown, Pennsylvania, the "king-size" gas light is 14 ft high, and weighs approximately 100 lb. The lantern proper, 27-in. square and 4½ ft tall, rests on a 10-ft post. A cluster of four burners produces the lighting.

Top Public Relations Program To Be Honored By A.G.A.

Gas industry's outstanding public relations program during the past year will be honored by the American Gas Association at its annual convention in Atlantic City this fall.

Winner of the fourth annual Public Relations Achievement Awards competition, along with several special classification leaders, will be chosen by the presidents of two national public relations societies and the editor of a leading gas industry magazine.

Serving as judges in the annual competition are **H. Walton Cloke,** president of the American Public Relations Association; **Kenneth Youel,** president of the Public Relations Society of America; and **Dean Hale,** editor of the American Gas Journal, Dallas. Cloke is public relations coordinator for Kaiser Industries Corp., Washington, D.C. Youel is assistant director of communications on the General Motors Corp. public relations staff in Detroit.

Top award last year was won by Michigan Consolidated Gas Co., Detroit, for its dramatic educational show, "Gasarama." Previous winners were Southern California Gas Co., Los Angeles, in 1957 and Quebec Natural Gas Corp., Montreal, in 1958.

Hawaiians To Help Thaw Alaskans

Despite the change of green tropical climes of the 50th state for the white frost-bound regions of the 49th, four key Honolulu Gas Company engineers plan to have home fires burning with natural gas in and around Anchorage, Alaska, by November. Loaned on an unusual management consultant contract, the four Hawaiians will help a group of Texas industrialists and financiers set up a new $4,000,000 distribution system to serve residents of Anchorage and the Public Utility District of Spenard.

Dale Teel, assistant to the general sales manager in Honolulu, transplants temporarily as executive vice president and general manager of the Anchorage Natural Gas Company. Howard Hole, plant superintendent, trades his short-sleeve shirt for a parka as operations manager. Merlyn Lyons, assistant treasurer, takes over the financial supervision of the new company and Merrill M. Ely, sales engineer, will help Teel set up a sales staff and provide technical assistance.

To supply the distribution system, Alaska Pipeline Corporation, parent company of Anchorage Natural Gas, is constructing an 80 mile, 12-in. pipeline (estimated to cost $12,800,000) to connect gas wells discovered last year on the Kenai Peninsula with the Alaska state capital. Meantime, mains and services in Anchorage are being laid in anticipation of natural gas by fall.

E. H. Smoker, president, The United Gas Improvement Co., Philadelphia, is the newly elected president of Pennsylvania Gas Association, succeeding W. C. Pierson, general superintendent of gas operations, Philadelphia Electric Co. Other officers elected are: First vice president, John E. Geesey, president, York County Gas Co.; second vice president, John H. Ware, president, Penn Fuel Gas, Inc.; third vice president, Roger A. McShea, Jr., vice president, Scranton Spring Brook Water Service Co.; secretary, Henry F. Dimmler, executive assistant, Philadelphia Electric Co.; and treasurer, A. Ray Thomson, paymaster, Philadelphia Electric Co.

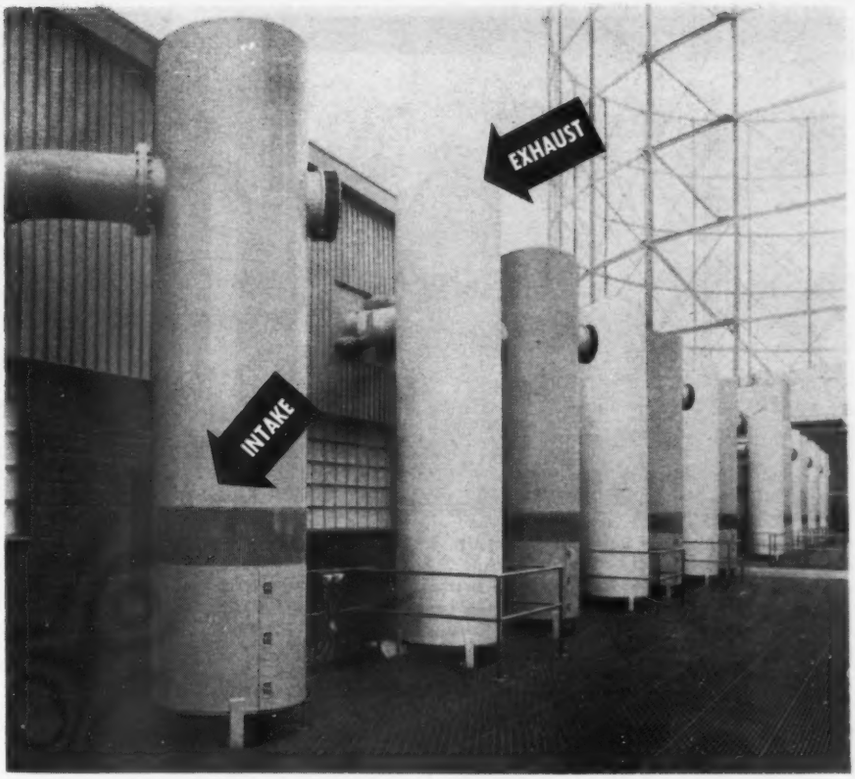
'Festival of Flame' Exhibit will highlight the American Gas Association 1960 annual convention Oct. 9-12 in Atlantic City. More than 200 of the newest and most significant technical developments in gas utilization and gas industry operation will be on display — everything from magnetic tape meter reading for high-speed billing, live demonstrations of sonic leak detectors, gas-engine-driven air conditioners, Robertshaw-Fulton's low temperature oven control, an automatic gas coffee maker developed by Oklahoma Natural Gas Co., and an internal corrosion detector developed by United Gas Corp. and a gas-fired device that generates 200 watts of electricity. Twice as large as the "Parade of Gas Progress" exhibit held at the 1958 convention, the A.G.A.'s new "Festival of Flame" exhibit will occupy the entire 90,000 sq ft exhibition hall of Atlantic City's newly renovated convention hall.

New Fuels for the Fuel Cells. Exide Industrial has unveiled a new fuel cell that in a decided departure from conventional propane, hydrogen fuels, is using zinc as its fuel. Along with zinc, Exide uses low-pressure oxygen as oxidizer, potassium hydroxide as electrolyte. Electricity is produced by oxidation of zinc electrode. The device using 18-cell, 1.5 volt per cell unit, operates at 80 percent efficiency and delivers 2 kw of power. Mounted with an oxygen cylinder, the compact power package has been used to drive a small (200 lb) racer 16 hours of continuous operations. Advantages claimed are operation at near ambient temperatures and pressures thus avoiding excessive corrosion; also, it is rechargeable, and can be produced in variety of shapes. **Another development** — General Electric recently disclosed details of its new "solid electrolyte" fuel cells — 10 of which it is delivering to the Navy for Marine Corps use. Similar to the H_2O_2 cells, GE's newest converts hydrogen and oxygen directly to electricity; heart of the new idea is an acidic ion exchange member that acts as an electrolyte. This eliminates the problems of aqueous and molten salt electrolytes used in other cells and gives GE what it likes to call a "rugged" unit. Each cell has a membrane 0.030-in. thick, covered with a thin Pt-Pd coating that acts as catalyst and electrode. Cell operates at about 0.8 volts; any voltage can be obtained by hooking cells in series. Power rating for cell is about 20 watt per sq ft of membrane; thermal efficiency is about 50 percent at full load.

Latest news on the direct energy conversion devices points to the continuing interest of engineers and scientists on the subject. For detailed report of specific interest to the gas industry on new methods of generating electricity from gas sources, see page 12.

Power Without A Turbine. Westinghouse Electric Corporation claims it has produced about one watt of power by hooking a small nuclear reactor to what it describes as a combination thermoelectric and thermionic device, that eliminates the need for a turbine in the power system. The experiment was carried out at the Waltz Mill, Pa., test facility. Heat of fission inside the nuclear reactor was converted into electricity by passing the heat into a horseshoe-shaped device surrounding the reactor. This device was made of two parts — a coil of lead telluride, and a thermionic apparatus containing a gas and a small magnet. The lead telluride coil turned out electricity when it was heated. Gas in the thermionic apparatus when heated lost electrons and these electrons were carried off into a circuit by the magnet. Together the two devices produced about one watt of power, or enough power to light a small lamp an instant.

More significantly, Radio Corporation of America has developed a simple, inexpensive thermionic conversion tube that can convert up to 14 percent of the heat energy derived from conventional sources, such as burning gas, into electricity. Although developed primarily for converting solar heat to alternating or direct current for use in space vehicles, RCA suggests such electrical energy may some day be used in consumer products. Dr. Karl G. Hernqvist of RCA's David Sarnoff Research Center said new technique permits maximum flow of electrons to be generated from a lower heat than in previous applications of the principle.



Eight SILENT TWINS Team Up To Eliminate Neighborhood Noise At California Gas Compressor Station

Rigid noise level requirements were issued by Southern California Gas Company for their Ducommun Street Station in the heart of Los Angeles. Burgess-Manning designed to the specifications, and guaranteed the performance of eight Silent Twins that were installed on each of eight Ingersoll-Rand gas engine driven compressors in the plant.

Silent Twins, matched units for remote-mounted or engine-mounted turbochargers, provide clean, filtered intake air at minimum pressure drop and maximum silencing efficiency on both the intake and exhaust sides of the system. Available for vertical or horizontal installation, they afford flow-conditioned, compact piping for best operating efficiency.

Silent Twins can be furnished with either two types of filters: a petrolatum-treated hogshair, used on the Gulf Coast, the Eastern United States, and other light dust load areas; for heavy dust load areas, we recommend a special felt material that will hold or load up with dust and dirt of a very small micron size.

Burgess-Manning Silencers are scientifically engineered to prevent — not muffle — exhaust noise of internal combustion engines, discharge of rotary blowers, and the intake of reciprocating compressors and rotary blowers. Silencing is obtained by passing the flow through snubbing chambers so that it is discharged to atmosphere smoothly and quietly. Burgess-Manning Snubbers are built like pressure vessels, continuously welded throughout, without excessive weight. A wide range of both standard and special units is available for 1" through 30" and larger pipe sizes.

In our more than 50 years' research and engineering for all types of industries, we have never failed to solve a noise problem. If noise is a problem in your plant, talk to "The Sound Engineering People." There's no obligation, and you'll find us anxious to help you in any way we can. Burgess-Manning Company, 9245 Sovereign Row, Dallas 7.

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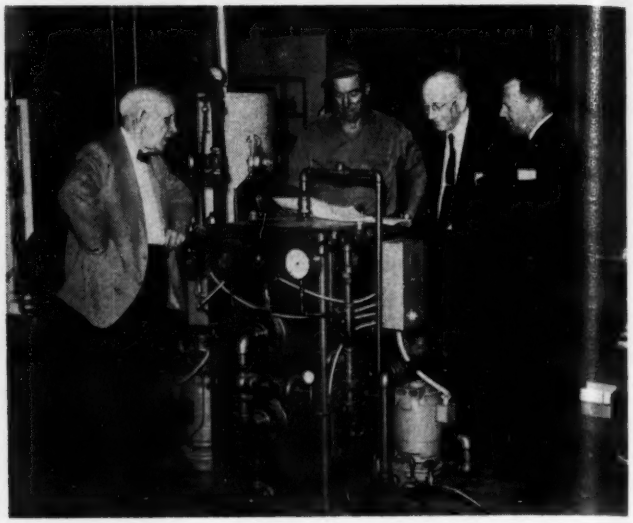
Brooklyn Union's New Building Going Up. Brooklyn Borough president John Cashmore, right, checks plans with John E. Heyke, president of The Brooklyn Union Gas Company as first structural steel swings into place for utility's new 14-story general office headquarters. Planned as an imposing addition to Brooklyn's rapidly developing new civic center, the structure will be ready for occupancy in early 1962.



New device for preventing hot water system corrosion in school, hospital, motel and manufacturing plant installations. Thomas McGeachie, left, president, C. I. Baker Co., explains how device, developed and patented by C. I. Baker, (second from right) removes corrosion-causing gasses — notably oxygen — dissolved in water and discharges the freed oxygen into atmosphere as Perry E. Wacker, Baker service manager, and L. P. McIntire, far right, Lorain, Ohio, manager for Ohio Fuel Gas Co., listen.

Lone Star Leases Gas Air Conditioners

An unusual gas air-conditioning unit lease program, offering both business and residential customers summer comfort for a nominal monthly charge that includes maintenance and routine service without capital outlay, has been initiated by Lone Star Gas Company. The program, believed to be first of its kind in the Southwest, will be particularly attractive to business establishments who may accrue tax and conservation of working capital benefits by leasing instead of purchasing equipment.

First leased unit—a 4½-ton model—was installed May 20 in the office of Fort Worth Sand & Gravel Co.

The leasing program offers Bryant gas air conditioners which permit installation with a minimum disturbance to customer's property and are available in the 3 and 4½-ton models regarded as add-on units that can be installed outside a building and require no floor space.

The lease term is for a 12-month period. In addition to a $150 initial fee, monthly charges are $35 for a 3-ton, $45 for a 4½-ton unit. Monthly lease charge includes delivery, installation of unit, setting up of a concrete slab, installation of coils, water piping, thermostats and wiring. Some 85 units have been tabbed for the 1960 program, 20 each in Dallas and Fort Worth, and 15 for each Texas distribution region.

Michigan Gas Association's new president is A. V. Brashear, vice president and manager of operations of Michigan Consolidated Gas Co. He succeeds John B. Simpson, vice president in charge of gas operations for Consumers Power Co. Named vice president was Frank B. Adams, division manager of Consumers Power Co. Milton G. Kendrick, administrative assistant to the vice president in charge of sales for Michigan Consolidated, was elected to his seventh term as secretary and treasurer.

* * *

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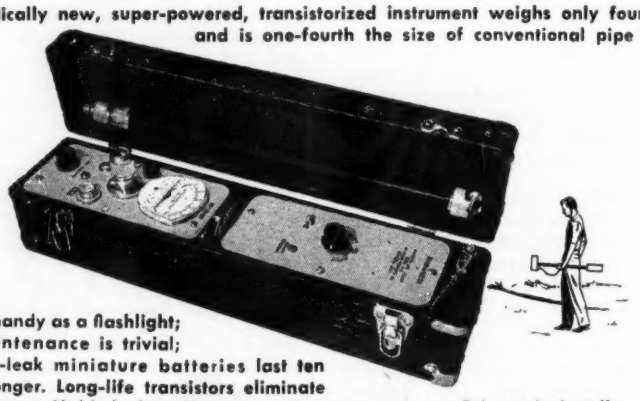

It is as handy as a flashlight; the maintenance is trivial; the non-leak miniature batteries last ten times longer. Long-life transistors eliminate replacement. Molded glass fibre cases. Transistor ear set. Telescopic handle. Etches circuitry and unique antenna. Contained in carrying case.

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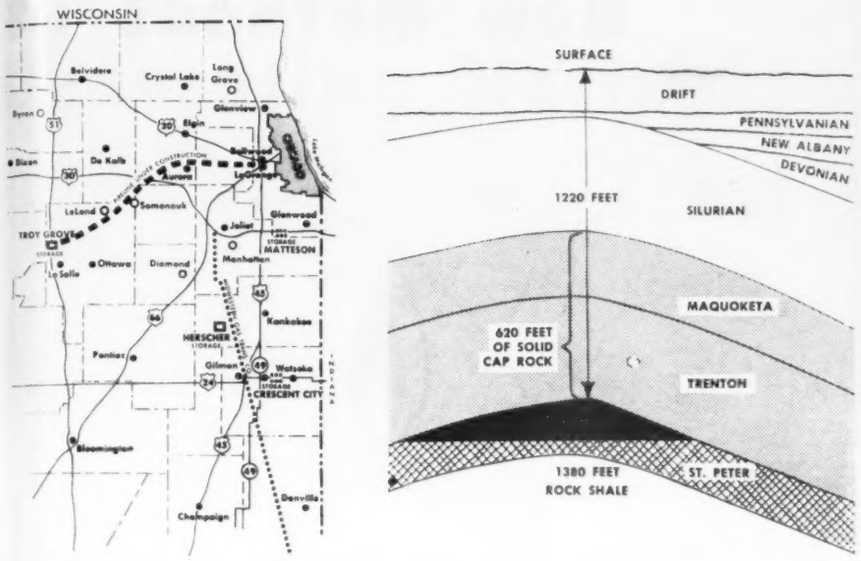


Territory map (left) shows NI-Gas' planned or proposed gas storage fields. Broken line indicates 75-mile pipeline under construction connecting Troy Grove storage with distribution system near LaGrange. South of Chicago, "bubble" storage (AGJ June 1960) at Matteson nears end of experimental stage. Latest development — new storage reservoir near Crescent City holds promise for 1961-62 winter. **Black-shaded area** of strata cross-section (right) at Crescent City storage site indicates where gas will be stored in the 1200-ft deep St. Peter sandstone. Dotted area indicates 620 ft of cap rock.

Northern Illinois Plans Another Aquifer Storage

Development of an underground storage reservoir near Crescent City, 25 miles south of Kankakee, will be undertaken by Northern Illinois Gas Company pending approval by the Illinois Commerce Commission. Similar to the Troy Grove storage reservoir near LaSalle put into operation this season, the new storage field will provide NI-Gas with approximately 100,000 Mcf of natural gas daily. Plans call for operation of the Crescent City storage by the 1961-62 heating season.

First probed for oil with no success, the 7500 acre storage site did show an inverted saucer-shaped St. Peter sandstone stratum at 1200 ft covered by 600 ft of solid rock that could be developed into a successful natural gas storage reservoir.

Once ICC approves the project, NI-Gas plans to construct an 11-mile pipeline from the storage site to a tap station near Midwestern Gas Transmission Company's Portland, Tennessee, to Joliet pipeline. Preliminary steps have been taken to obtain the supply of natural gas and NI-Gas has an option to buy one acre of the Clarence Medendorp farm, northeast of Gilman (25 miles southwest of Kankakee) and adjacent to Midwestern's line, for a tap station site. Injection of natural gas into the Crescent City storage is expected early this fall. Drilling operations now are concentrating on completing 8 storage wells in the area; three to be used for injection and withdrawal; the others for observation.

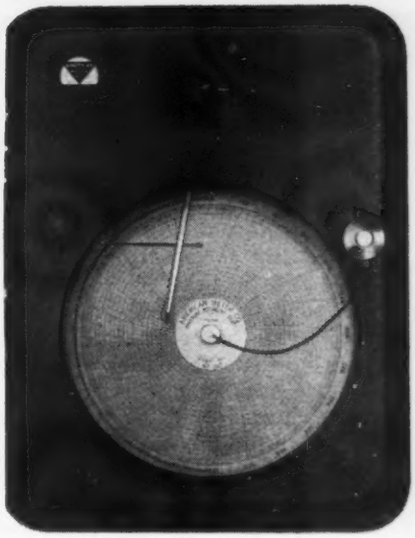
Appalachian Gas Measurement Short Course will be held August 29-31 at West Virginia University, Morgantown, West Virginia. Approximately 900 gas utility measurement and control engineers and technical personnel are expected to attend the 20th annual short course. Laboratory, classroom and forum sessions have been scheduled for the intensive 3-day course with sessions ranging from basic shop practice and testing, installation design, monitoring equipment and other related phases of regulation and measurement.

Baltimore Gas & Electric Co. plans to build and operate an underground propane gas storage plant on a 44.7 acre site at Harford Road and the south bank of the Big Gunpowder Falls in Baltimore county. Authorization came after a public hearing at which county zoning commissioner ruled the new storage plant would not interfere with development of the Gunpowder River Valley State Park or with construction of the Perring Park expressway.

Storage "Swap" Proposed By Texas Gas, Western Kentucky Gas

Texas Gas Transmission Corporation wants to swap its Hickory School and Grandview storage fields with a combined peak day withdrawal capacity of 21,500,000 cu ft for right to develop Western Kentucky Gas Company's West Greenville gas storage field to an 85,000,000 cu ft peak-day withdrawal capacity. Texas Gas proposes to construct approximately 29 miles of 12 in. line from the West Greenville field in Muhlenberg, Kentucky, to its main line facilities near Slaughters, Kentucky; a 1760 hp compressor station, dehydration plant, and a meter station at a cost estimated at $2,506,000 and purchase of Western Kentucky rights and interest in the storage field to bring the total cost of $3,561,527.

Once the West Greenville field has been developed to 21,500,000 cu ft of peak-day withdrawal capacity, Texas Gas proposes to abandon, by sale to Western Kentucky, rights and interest to its Hickory School and Grandview storage fields.



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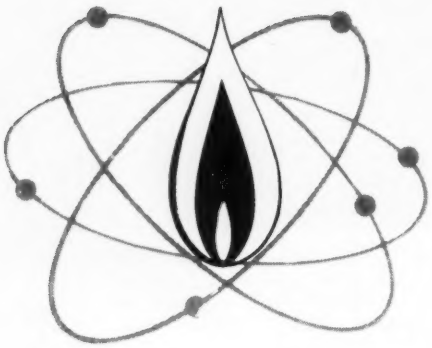
New Methods of



C. G. von Fredersdorff
Institute of Gas Technology
Chicago, Illinois

INTRODUCTION

DIRECT CONVERSION METHODS OF GENERATING ELECTRICITY have recently been given increased attention. The prime objective is development of a direct route for production of electrical energy from heat energy. The simplest, and therefore ideal, direct route is one having a single process step and minimum or no moving parts in the apparatus.

Three direct conversion techniques are explored in this report. Two of them, the thermoelectric or Seebeck generator and the thermionic converter, fall into the "ideal" category; the third, magnetohydrodynamic conversion, is less direct and requires some auxiliary machinery. These techniques are based on long-known principles:

(1) **Thermoelectric generator** relies upon the thermocouple effect between dissimilar metals,

(2) **Thermionic converter** operates by virtue of evaporation of electrons from a heated surface, and

(3) **Magnetohydrodynamic generator** depends upon the action of a magnetic field on a flowing ionized gas.

An associated thermoelectric phenomenon, the Peltier effect, depends upon the "heat pump" action of a reverse-operated thermocouple. This effect is useful for producing cooling and heating directly from an electric current.

Only within approximately the past five years has there been a really accelerated effort to search for and develop improved materials for more efficient thermoelectric and thermionic generators, and to explore the potential applications of these concepts. Yet they, together with the recently proposed magnetohydrodynamic conversion technique, are particularly suited to gas sources of energy.

Although all direct conversion methods presently known are costly, they nevertheless should be of interest to the gas industry, especially in those areas of small-scale application where costs and low thermal efficiencies are not a major consideration. Each of the above three methods is discussed here from the standpoint of development, material problems, efficiency and potential applications.

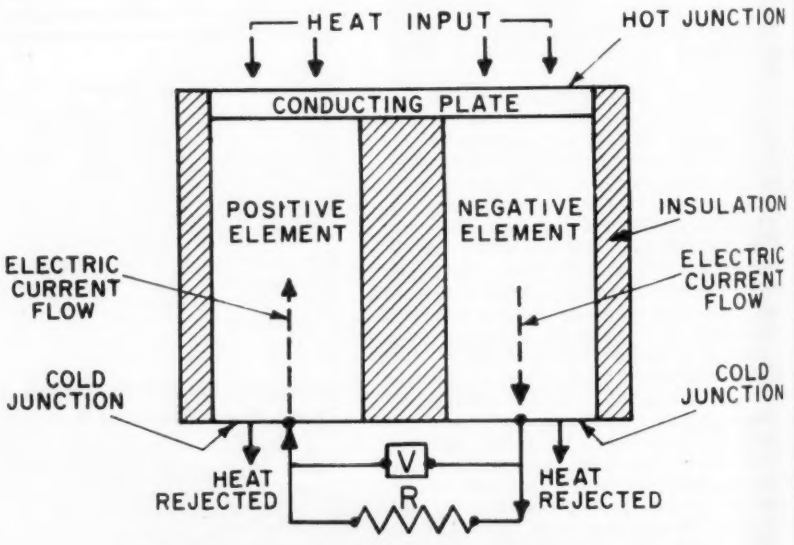


FIG. 1. **How Seebeck generator works** is shown in diagram.

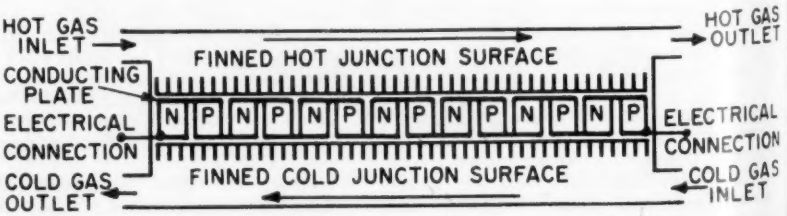

HOT GAS INLET
HOT GAS OUTLET
FINNED HOT JUNCTION SURFACE
CONDUCTING PLATE
ELECTRICAL CONNECTION
N P N P N P N P N P N P N P
ELECTRICAL CONNECTION
FINNED COLD JUNCTION SURFACE
COLD GAS OUTLET
COLD GAS INLET

FIG. 2. **Multiple thermoelectric element** version of Seebeck generator.

Generating Electricity From Gas Sources

I — THERMOELECTRIC EFFECTS

Their Development
Materials Used
Seebeck Generators
Peltier Cooling and Heating
Applications

THERMOELECTRIC EFFECTS

Development

Transformation of heat energy into a direct current of electricity was first observed by Seebeck, who found that a magnetic needle is deflected when it is held close to a circuit of two dissimilar conductors heated at one end. This was misinterpreted by the discoverer as a magnetic effect arising from temperature differences in a conductor. Much effort was spent by Seebeck in attempting to disprove his contemporary scientists who had correctly interpreted the phenomenon as a purely thermoelectric effect.

An associated effect was observed in 1834 by Peltier, who found small quantities of heat were emitted by passage of weak electric currents through junctions of dissimilar metals. This was also misinterpreted by the discoverer, as showing that Ohm's law may not be obeyed by a sufficiently weak electric current.

In 1838 the exact nature of Peltier's discovery was demonstrated by Lenz, who showed that a drop of water placed on the junction of dissimilar metals could be made to alternately freeze and melt by reversal of the direction of the electric current.

Because of these early misunderstandings of the true nature of thermoelectric phenomena, and the lack of suitable materials to make efficient use of them, practical applications lagged for more than 100 years. Seebeck actually unknowingly had tested several semiconductor materials that could have generated electricity from heat at 3% efficiency, comparable to the efficiency of the 19th century steam engine. About the only use of thermoelectric effects in the early years was temperature measurement by thermocouples, which generate current at only a fractional percent of efficiency.

Since the late 1920's and 1930's, interest in thermoelectric effects has been revived with the discovery of a class of compounds of low electrical conductivity known as semiconductors. Many applications developed.

Examples are rectification of alternating current by copper oxide or selenium rectifiers, measurement of light intensity by photoelectric cells, conversion of solar energy into electricity by silicon cells, use of transistors as a substitute for electronic tubes, conversion of small quantities of nuclear energy into electricity by "nuclear batteries," cooling of small electronic components by the Peltier effect, and production of small quantities of electric power (in USSR)[20,21] from kerosine-lamp or stove-heated Seebeck generators for operating radios and refrigerators.

Recent development work in the United States has been directed mainly toward application of the Peltier effect for refrigeration[6,23,26,28] although there is moderate but increasing interest in developing Seebeck generators.[2,33]

Thermoelectric Materials

The thermoelectric properties of semiconductors like lead sulfide (PbS), and metallic compositions like lead telluride (PbTe), are greater by a factor of 10 or more than those of full-conducting metals, such as copper and iron. This difference may be explained qualitatively (the complete explanation is very complex[4,5,15,18,20,30,31]) on the basis that ordinary conducting metals have loosely bound valence electrons (outer-shell electrons) that are free to move when a voltage is applied, whereas the valence electrons of semiconductors are tightly bound, resulting in lower electrical conductivity. Restated, the concentration of free electrons in semiconductors is much lower (by factors of 100 to 10,000) than in conductors.

When a metal (full-conductor) is heated at one end, the free electrons at the hot side are caused to move at relatively higher speed, and an accumulation of excess electrons occurs at the cold end, which becomes negatively charged. The negative charges repel each other, however, and due to the high concentration and high mobility of electrons in metals (low electrical resistance), these repulsive forces drive most of the electrons back to the hot side.

The net result is that, at equilibrium, only a small thermoelectric voltage (Seebeck effect) is developed, on the order of several millionths of one volt

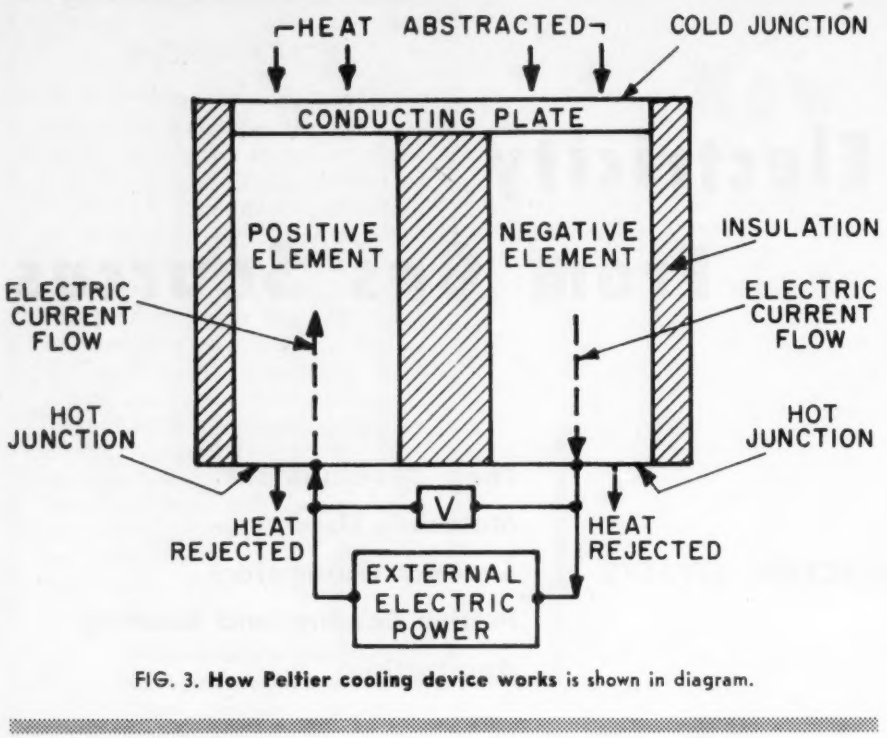


FIG. 3. **How Peltier cooling device works** is shown in diagram.

per degree Fahrenheit temperature difference.

This same effect occurs in semiconductors (and also in insulators), except that now the lower concentration and lower mobility of electrons (higher electrical resistance) does not result in so rapid a repulsion of the electrons from the negatively-charged cold side.

Net effect in this case is a greater thermoelectric voltage, on the order of a few ten thousandths volt per degree Fahrenheit temperature difference (Seebeck effect).

By connecting enough semiconductors in series through an external circuit, sufficient power can be derived to drive an electrical device. Here, in effect, the action of heat is to "pump" electrons through the circuit.

Ordinary conducting metals, such as copper, zinc, or lead, become semiconductors when compounded with a nonmetal element such as oxygen or sulfur, which forms bonds with the valence electrons. Examples are lead sulfide, copper oxide, and zinc sulfide crystals.

These or similar compounds, however, do not function efficiently as a thermoelectric generator because of high electrical resistance and other unsatisfactory physical properties.

The best combination of properties for maximum efficiency of thermoelectric materials is

(1) high thermoelectric voltage or Seebeck emf,

(2) low electrical resistance, and

(3) low thermal conductivity.

Full conducting metals are unsatisfactory because of low Seebeck emf's and high thermal conductivities. Compounds of metals with nonmetals are better because of higher Seebeck emf's and lower thermal conductivities, but generally are still unsatisfactory due to high electrical resistance. Certain high-temperature ceramics[32] and ionic crystals, such as silver iodide and silver bromide,[24] appear to be promising materials. Westinghouse Research Laboratories, for example, are developing ceramic-type thermoelectric substances composed of intermetallic compounds of transition elements which may be capable of withstanding 2000 F or more at promising thermal efficiencies.[32]

Other very promising materials under development at Minnesota Mining and Manufacturing Company and elsewhere are intermetallic compounds of heavy elements (compounds or alloyed mixtures of two or more metals), such as tellurium selenide,[9,22] lead telluride,[7,9,22] bismuth telluride,[20,28] and manganese telluride,[27] activated with small concentrations of positive- and negative-conducting promoters.[8] These materials have a low thermal conductivity and relatively high electrical resistance.

The function of the positive and negative promoters is to improve the electrical conductivity and increase the Seebeck emf. The combination of a positive and a negative conducting element as the two legs of a thermoelectric generator yields the highest Seebeck emf and the highest potential efficiency of conversion of heat into electricity of any of the thermoelectric devices developed thus far. This combination of positive and negative conducting elements also yields the best coefficients of performance thermoelectrically for cooling and heating by the Peltier effect.

Promoted intermetallic thermoelectric elements are relatively costly at present, as strict manufacturing control is needed in the alloying and promoter-compounding steps. They cannot generally be operated at much above 800 to 1000 F, or above the melting points of the alloys. Westinghouse has recently announced a new three-element semiconductor composed of indium, arsenic, and phosphorous. It is claimed to be the most efficient thermoelectric material yet discovered for the operating range 850 to 1500 F.[33]

Seebeck Generator

A thermoelectric or Seebeck generator is, in principle, nothing more than several "thermocouples" in series. It is basically a low-voltage, high-current device. A single unit generator (Fig. 1) consists of two dissimilar thermoelectric elements joined in electrical contact at one end, which we call the hot junction and connected to an electric circuit at the other end, the cold junction. The heat supplied to the hot junction is partly converted to electrical power; the remainder of the heat is conducted to the cold junction, where it is rejected as low-temperature waste heat. The lateral faces of the thermoelectric elements are insulated to prevent excessive heat losses. Thermoelectric elements may be of any convenient geometric shape, such as pellets, rings, cubes, rods or cylinders.

In operation (Fig. 1), the temperature difference between hot and cold junction produces a Seebeck voltage in both the negative and positive conducting elements. These voltages are additive and are indicated by a voltmeter, **V.** By connecting through an external circuit the Seebeck voltage produces an electric current that does useful work in the load resistance **R.**

Electric current flow is in the clockwise direction in the diagram; down through the negative element, through the load resistance and up through the positive element. In the negative element, the current flow is due to the movement of electrons in the direction of the heat flow, while in the positive element the current flow is produced by movement of positive charges in the direction of heat flow.

A practical Seebeck generator requires many thermoelectric elements connected electrically in series to provide a useable output voltage. For example, a single set of elements may produce 0.022-v for every 100 F tempera-

ture difference between the hot and cold junctions. At a maximum temperature difference of 1100 F, each unit would yield 0.24-v, so 100 sets of elements would be required to develop an open circuit 24-v. When maximum power is drawn from the Seebeck generator, approximately one-half of the voltage appears over the external load; the other half of the voltage is required to overcome internal resistances. Therefore, in this case about 200 sets of elements are required to develop 24-v under actual load conditions.

A possible arrangement of a multiplicity of single-stage thermoelectric elements connected in series is shown in Fig. 2. This is merely an extension of Fig. 1. Each element would be a solid rectangular block of thermoelectric material, interconnected negative to positive with conducting plates, such as copper strips. The entire array is enclosed in a finned metal casing, that is insulated from the conducting plates, and the gaps between the **N** (negative) and **P** (positive) elements are also insulated. The assembly with casing is enclosed with gas ducts above and below.

The upper duct provides high-temperature flue gasses to heat the hot junctions of the generator. The lower duct supplies heat-absorbing gas or other cooling medium to maintain the cold junctions of the generator at suitably low temperatures. An arrangement like this might be made a part of the walls of a gas furnace, or of the flue gas lines. It has been estimated that a Seebeck generator of 1-kw capacity would require an array of thermoelectric elements measuring about 1 sq ft in area, and about 0.5-in. thick.[11] The investment cost should eventually be no more than the $225 to 250 per kw capability for small steam power stations. At the present prices of thermoelectric materials, however, the estimated cost is on the order of $1000 to 2000 per kw.

There are a number of factors that affect the thermal efficiency of conversion of heat to electricity.[20] Briefly, the overall Seebeck efficiency, E_s, is given by the ratio of useful external power, W, to the total heat input rate, Q_i, at the hot junction: $E_s = W/Q_i$.

The quantity W depends upon the hot and cold-junction temperatures, the thermoelectric properties and geometric shape of the elements, and the ratio of external load resistance to internal resistance of the elements.

Factors that contribute to loss of efficiency and enter into the calculation of Q_i are

(1) heat losses to the cold junction and through insulation, and

(2) power losses through internal electrical resistance and electrical contact resistance at the hot and cold junctions.

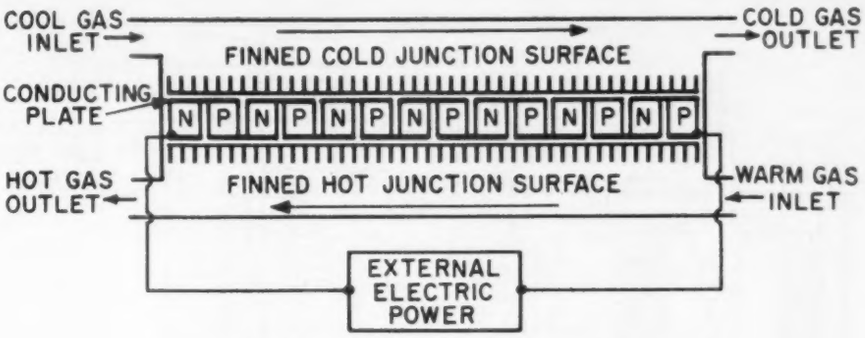

COOL GAS INLET
COLD GAS OUTLET
FINNED COLD JUNCTION SURFACE
CONDUCTING PLATE
N P N P N P N P N P N P N P
HOT GAS OUTLET
FINNED HOT JUNCTION SURFACE
WARM GAS INLET
EXTERNAL ELECTRIC POWER

FIG. 4. **Multiple thermoelectric element** Peltier unit.

Calculations for an ideal generator based on the properties of the best present thermoelectric materials indicate that theoretical efficiencies up to 10% should be attainable with a single stage at hot-junction temperatures up to 1200 F. With a 30% improvement in thermoelectric materials, this single-stage efficiency could be increased to 12.5%. Thermal efficiencies approaching 20%, in the range of more practical interest, would require about 300% improvement in thermoelectric materials.

In present practice, Seebeck generator efficiencies of 4 to 6% are achievable, approaching 8.5% with the more favorable thermoelectric materials, depending upon the temperature level and temperature differences. Examples are 3 to 4% efficiency of pilot-operated thermoelectric flame controls, and 5.5% efficiency of a recently constructed AEC radioisotope fueled (SNAP-III-B) thermoelectric generator.[2] Russian experimental work indicates 6 to 10% efficiency of thermoelectric generators,[20] depending upon good quality semiconductor material and the temperature conditions.

Each of the present thermoelectric materials operates at its best efficiency over only a small temperature range. Thus, with a Seebeck generator where the temperature might range from 1500 F at the hot junction to 100 F at the cold junction, the best possibility of efficiency improvement would be through "cascading" or "staging" materials of different temperature limitations. Here a series of thermoelectric stages are so connected that the waste heat from one stage would be used in the succeeding stage. Scientists foresee possibilities of achieving efficiencies of 20% or more by this technique.

Peltier Cooling or Heating

A schematic diagram of a single-unit Peltier cooling or heating device is shown in Fig. 3. It is similar to the Seebeck generator (Fig. 1), but now the voltage, **V**, from an external electrical source causes heat to flow in the same direction as before, but with the junction temperatures reversed. Electric current flow is in the clockwise direction in the diagram; down through the negative conducting element, through the power source, up through the power source, up through the positive conducting element **P**, and across the conducting plate connecting the elements.

The "heat pump" effect of the Peltier unit forces heat to flow from the cold junction to be rejected at the hot junction. Useful cooling is achieved by placing the area to be cooled in thermal contact with the cold junction. Heating is achieved by utilizing the heat rejected from the hot junction. The junction temperatures are reversed by reversal of the electric current flow.

As with the Seebeck generator, a practical Peltier cooling or heating unit requires a multiplicity of thermoelectric elements connected electrically in series. The number of elements depends mainly upon the voltage of the external power supply, desired temperature difference between hot and cold junctions, thermoelectric properties, and whether single or two-stage units are used. A typical single set of good elements requires 0.11-v per 100 F temperature difference of the junctions. Of this total voltage about 25% is needed to overcome the Peltier emf, and the remaining 75% drives the electric current through the internal resistances. Thus, if 12 volts is supplied and a 60 F junction temperature difference, is desired, about $12/(0.11 \times 0.60)$, or about 180 sets of elements are required.

Fig. 4 is a schematic flow system for a Peltier cooling or heating unit consisting of a multiplicity of single-stage thermoelectric elements. It is similar to the Seebeck generator flow system (Fig. 2) except for external power supply

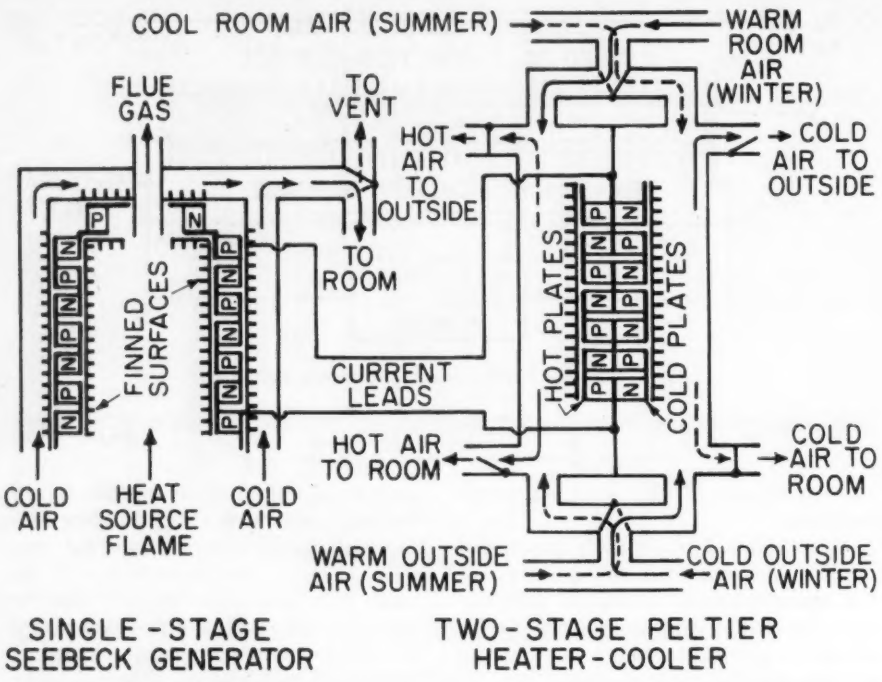


FIG. 5. **Thermoelectric space-conditioning unit** would use a single-stage Seebeck generator plus a two-stage Peltier heating and cooling unit.

and the hot and cold junctions reversed. In operation, inlet cool gases are progressively further cooled by heat transfer to the cold junctions. The heat abstracted at the cold junctions is rejected at the hot junctions by transfer to heat absorbing warm gases.

Overall performance or efficiency of Peltier cooling is expressed in the same way as for conventional cooling devices. This measure is the coefficient of performance (COP) for refrigeration, denoted by the symbol C_R, and is defined by the ratio of the useful refrigeration, rate Q_R, to the total external power consumed, W:

$$C_R = Q_R/W.$$

The quantities Q_R and W depend upon the hot and cold junction temperatures, the thermoelectric properties and geometric shape of the elements, and the internal resistance of the system.[20]

Factors that contribute to loss of COP are

(1) transfer of heat by conduction from the hot junction back to the cold junction,

(2) internal (Joulian) heat generation, a portion of which appears at the cold junction to diminish the overall refrigerating effect, and

(3) electrical losses through internal and junction resistances.

The overall performance or efficiency of Peltier heating is expressed in a manner similar to that for Peltier cooling. This measure is the COP for heating, denoted by the symbol C_H, which is defined as the ratio of heating rate at the hot junction, Q_H, to the total external power consumed, W:

$$C_H = Q_H/W.$$

Factors which enter into the calculation of C_H are essentially the same as those encountered in estimation of C_R.

The COP of Peltier cooling is greatly dependent upon the difference of temperature between the hot and cold junction of the device. For 10 to 20 F cooling effects, the COP is in the range 2.5 to 7.0, which exceeds that of conventional compression-cycle cooling equipment. At 30 F cooling effect, the COP is about 1.5 to 2.5, however, at utilizable temperature differences, say 60 to 65 F, the COP falls below 1.0, usually to the range 0.4 to 0.8, with present thermoelectric materials. About 400% improvement in thermoelectric material properties is needed to realize the 2.0 COP of conventional equipment.

The COP for heating by the Peltier effect is likewise greatly dependent upon the temperature difference between hot and cold junctions. For 20 to 35 F heating effects, it is in the 2.5 to 5.0 range, which compares favorably with electric heat pump coefficients. For 60 to 70 F temperature differences, however, Peltier heating performance coefficients fall below 2.0, usually to 1.4 to 1.6, with the present best thermoelectric materials. Russian work indicates a heating COP of 1.5 to 1.8 for 70 F temperature difference, depending upon the type of thermoelectric material.[20] The conventional electric heat pump has a COP of 2.0 to 2.5 and up to 3.5 under the best conditions.

An improvement of 50 to 100% in thermoelectric properties is needed to attain a COP of 2.0 to 2.5 for Peltier heating.

Applications of Thermoelectric Effects

Recent programs of the AEC, Armed Services, and the National Aeronautics and Space Administration have given impetus in the United States toward the development of compact, portable, thermoelectric generators. To mention a few, the Martin Company constructed a 5-watt radioisotope-fueled demonstration unit, and larger units are being planned. Minnesota Mining and Manufacturing Company converted an identical 5-watt unit to butane gas firing. Recently, the Air Force disclosed a more powerful thermoelectric generator that delivers 100 watts at a rate three times as high per pound of weight as previous units. This unit can operate with propane, or could be converted to operate with gasoline or kerosine. A Navy contract with Westinghouse calls for the construction of a 5-kw thermoelectric generator as a prototype of shipboard installation.

Considerable development of Peltier cooling or heating devices has occurred in the United States. This has ranged from small experimental units for controlled temperature chambers to prototype units of the size that might be used in home refrigerators or in thermoelectrically operated wall panels for space conditioning.[26] In particular, a prototype device to be built for the Navy will combine into one system a one-ton thermoelectric air conditioner, space heater, and 2 cu ft refrigerator-freezer capable of maintaining 0 F.

A possible arrangement of a thermoelectric space conditioning unit is outlined in Fig. 5. The system comprises a gas-fired Seebeck generator that supplies electric power to drive a Peltier heating-cooling unit. Ductwork suitably dampered would permit switchover from heating or cooling operation. During the heating period cold air which abstracts heat from the Seebeck generator cold junctions, is delivered as hot air to the room. The electric power from the Seebeck generator delivers additional heat via the Peltier unit. The latter operates (during heating) with recycled room air over the hot junctions and cold outside air over the cold junctions. Alternatively, some flue gases from the Seebeck generator could be mixed with outside cold air before passing over the Peltier unit

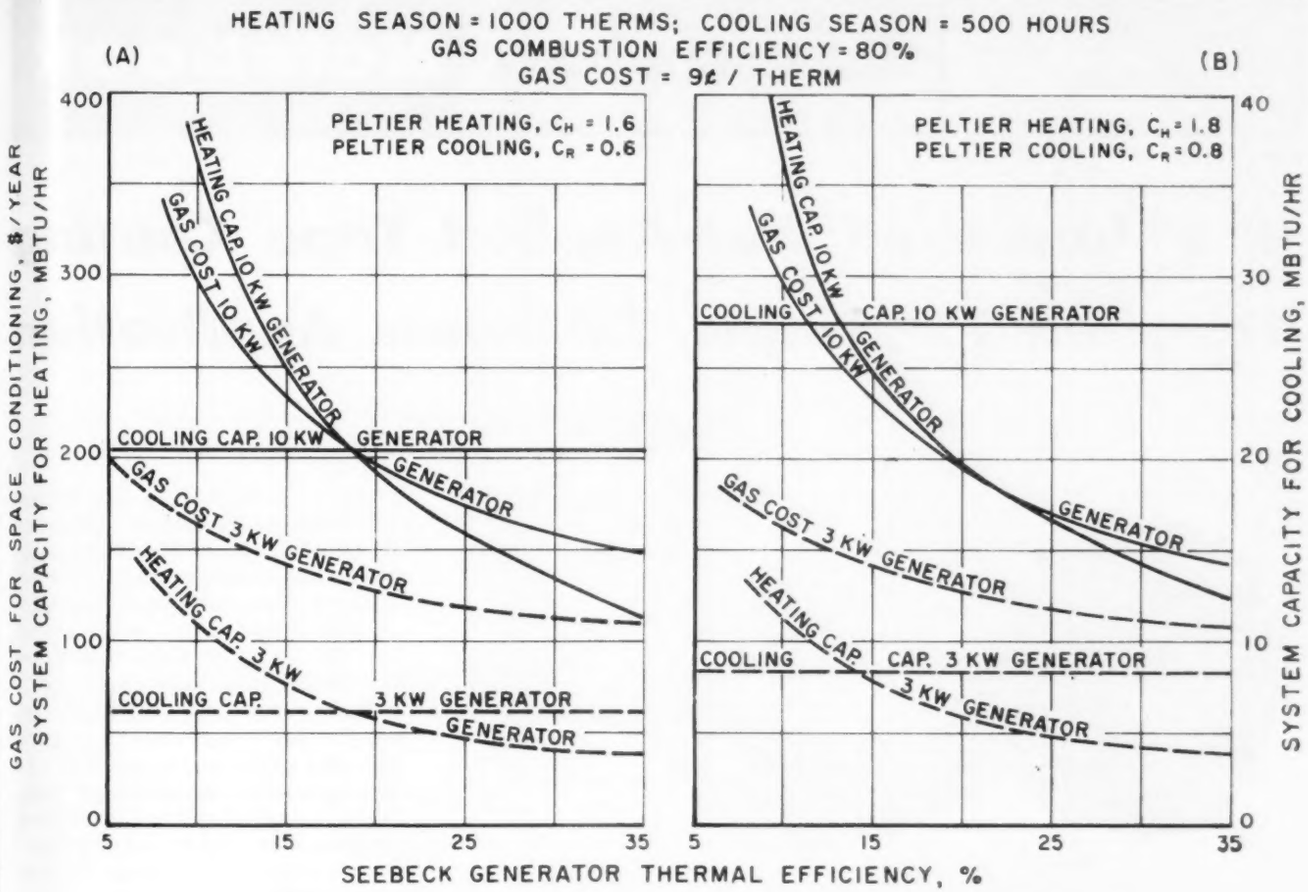

HEATING SEASON = 1000 THERMS; COOLING SEASON = 500 HOURS
GAS COMBUSTION EFFICIENCY = 80%
GAS COST = 9¢ / THERM
(A)
(B)
PELTIER HEATING, C_H = 1.6
PELTIER COOLING, C_R = 0.6
PELTIER HEATING, C_H = 1.8
PELTIER COOLING, C_R = 0.8
HEATING CAP. 10 KW GENERATOR
GAS COST 10 KW GENERATOR
COOLING CAP. 10 KW GENERATOR
GAS COST 3 KW GENERATOR
HEATING CAP. 3 KW GENERATOR
COOLING CAP. 3 KW GENERATOR
GAS COST FOR SPACE CONDITIONING, $/YEAR
SYSTEM CAPACITY FOR HEATING, MBTU/HR
SYSTEM CAPACITY FOR COOLING, MBTU/HR
SEEBECK GENERATOR THERMAL EFFICIENCY, %

FIG. 6. **Estimated fuel costs** and capacities for thermoelectric space conditioning (heating and cooling).

cold junctions (to increase the COP).

During the cooling period, the heated air is vented from the cold junctions of the Seebeck generator. Only the Seebeck electric power is used to perform cooling via the Peltier unit, which operates with outside air over the hot junctions and recycled room air over the cold junctions. This system is analyzed on the basis of representative assumptions about the COP of Peltier heating and cooling with a fixed electric power output of the Seebeck generator, 80% gas combustion efficiency in the Seebeck generator, heating season requirements of 1000 therms, 500 operating hours for cooling, various Seebeck generator efficiencies for electric power, and a nominal gas cost of 9¢ therm. Fig. 6A and 6B illustrate the results for

(1) Seebeck generator electric power capacities of 3 and 10 kw, and

(2) Peltier heating and cooling COP of 1.6 and 0.6, and 1.8 and 0.8, respectively, plotted against Seebeck generator thermal efficiency for electric power.

Since the Seebeck generator electrical output was assumed fixed, the Peltier cooling capacity is fixed, but the heating capacity in Btu per hr, and the yearly gas cost, decrease with increasing Seebeck generator thermal efficiency. At Seebeck generator thermal efficiencies presently achievable, 5 to 10%, it will be observed that the system heating and cooling capacities are out of balance and the fuel costs are probably too high.

For example, at 10% Seebeck generator efficiency in Fig. 6A, the system heating capacity for a 10-kw Seebeck generator is 363,000 Btu per hr, whereas the cooling capacity is 20,500 Btu per hr, 1.71 tons of refrigeration, with a total gas cost of $298 per yr. This means that while sufficient cooling may have been achieved at full load, the heating system would operate at approximately ⅓ full blood to achieve normal specifications of say a 100,000 Btu per hr heating rate.

Analogously, a 3-kw Seebeck generator at 10% efficiency (Fig. 6A) yields a system full-load heating rate of 108,000 Btu/ per hr, thus closely fulfilling specifications, but the system cooling capacity is only 6200 Btu per hr, approximately ½-ton of refrigeration.

Slightly better results are possible if Peltier heating and cooling COP of 1.8 and 0.8, respectively, can be achieved in practice (Fig. 6B). However, a significant improvement in fuel costs and balance between heating and cooling capacities will depend upon future improvement of the Seebeck generator thermal efficiency for electric power.

In summary, the potential applications of thermoelectric devices are presently limited to generation of small amounts of direct-current electric power from heat, or production of small cooling and heating effects from direct-current electric power in such instances where costs and low conversion efficiencies are not an important consideration. These areas of application can be expected to grow as improved and less costly thermoelectric materials are developed.

Possible interests to the gas industry lie in

(1) utilization of waste heat in flue gases for auxiliary power in electric controls,

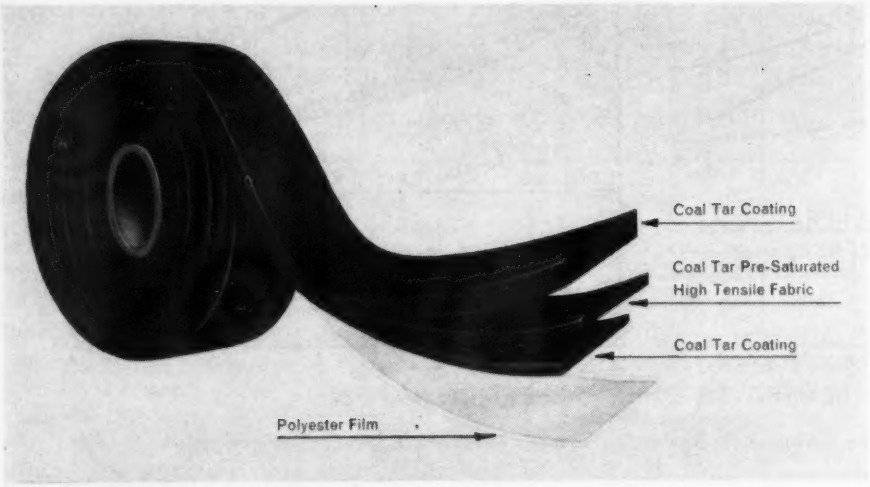
(2) application to cathodic protection of pipelines and underground equipment,

(3) gas-fired refrigerator based on Peltier cooling unit driven by direct current from a Seebeck generator, and

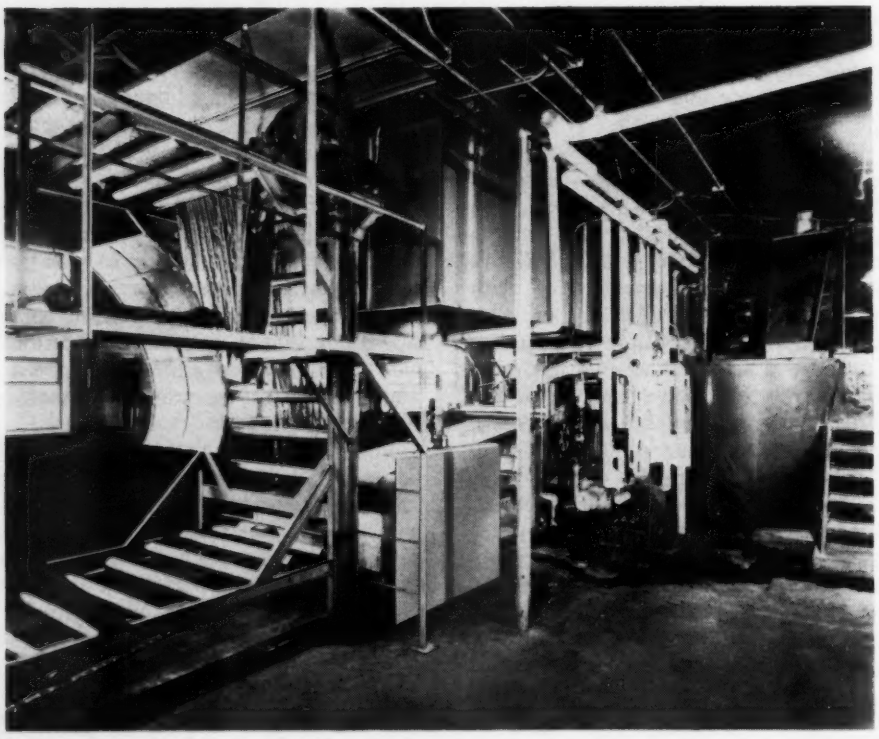
(4) extension of these concepts to year-round space conditioning. * *

New Improved Hot-Applied Tape Coating Designed for Single Thickness Application

Dean Hale, *Editor*



Exploded view of new protective tape coating shows arrangement of layers. Film serves as separator in roll, outer wrap for tape after application.



Single unit machine was specially designed to produce the new tape coating in one continuous operation.

TWENTY YEARS AGO, an entirely new and improved method of protecting field welded pipe joints and fittings on steel pipe distribution systems was introduced. Gas distribution engineers, construction men, and maintenance men quickly adapted the method and have used it successfully since.

The new method of two decades ago was a protective coating in tape form, that combined a fabric saturated with coal tar enamel. In subsequent years, the success of protective tape coatings has been evidenced by introduction of numerous types of tapes in the pipe coating field.

Newest tape coating to be introduced is a coal tar product, designed for single thickness application, that incorporates many improvements brought about by continuing research in the protective coatings field.

The story of the new tube product began five years ago with the building of a research laboratory by the manufacturer. Major purpose of the lab was to examine all coating materials on the market, to check new materials as they were evolved, and, in short, to combine the best of the old with the best of the new to produce even better protection in tape form.

In the research process, literally hundreds of formulations were tested. Experimental equipment was built to probe different manufacturing methods.

Result: An entirely different tape that incorporates a greatly improved coal tar coating material, produced on an entirely new type of single-purpose machine that was designed and constructed to convert raw materials into a finished product in one continuous operation.

Product Improvements

The new tape consists of a high-tensile-strength fabric, completely saturated with a specified coal tar pitch that provides a compatible base for a more pliable coal tar coating material on the tape. The coating material is

accurately gaged for thickness by the special machine, with tapes tailor-made to individual user requirements.

Characteristics of the improved coal tar coating material formulation make the tape ideal for single-thickness wrapping.

Application follows standard industry practice of priming the pipe and/or fittings, and then hot-applying the tape by hand, using a torch to bleed the pitch. Only minimum overlaps are needed, and the single thickness method eliminates the necessity for special skill in proper lapping procedure.

Simultaneously, flowability of the pitch is retained for efficient application by torching methods, and good conformation to irregular surfaces is assured.

What Makes Tape Different?

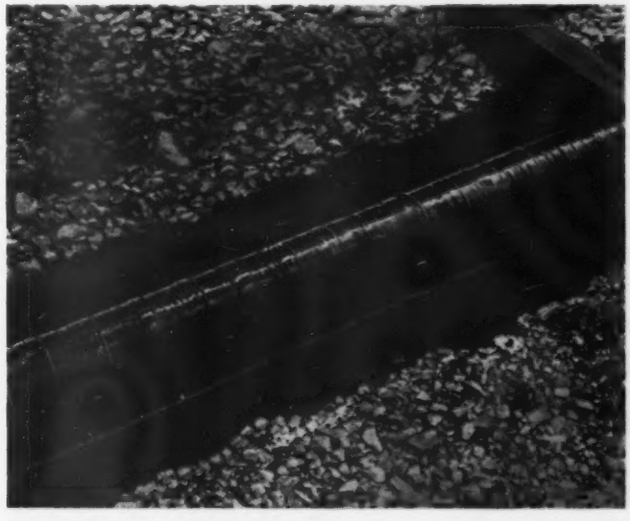
A distinguishing feature of the new tape is that it is more than just a coating. It provides both coating and wrapping benefits at the pipe joint that are compatible with and equivalent to hot-applied coated and wrapped mill protection on the pipe.

This has been accomplished by combining the coal tar pitch coating with a tough outer wrapping of polyester film. This film is imbedded in the side of the tape that is not in contact with the pipe.

In the application process, heat is applied to that side of the tape opposite the polyester film. The heated side is placed in contact with the pipe. The film, then on the outside, becomes an outer wrap and provides an additional mechanical barrier and extra reinforcement for protecting the coating against impact, soil stress, and other abrasive conditions. It serves much the same purpose as the wrapper on mill-wrapped pipe in protecting the coating. The film also serves as a separator in the roll.

Initially, the tape will be available in standard length rolls in widths of 2, 3, 4, and 6-in. * * *

Coating material formulations and processes for manufacturing were studied in research and development laboratory for five years during development of new tape.



Single thickness application with minimum overlap eliminates need for special skill in lapping procedures.

Standard length rolls in four sizes — 2, 3, 4, and 6-in. widths — meet most distribution application requirements.

Minneapolis Landmark . . .

World's Biggest Gas Light

World's biggest gas light is lit by wave of a wand in hands of Gail Nygaard, "Queen of the Lakes" during the Minneapolis Aquatennial, the city's famous summer festival. Nearly 29 ft high, the light beams 13,000 candlepower at a busy intersection in northeastern section of the Minnesota city. The light is 8¼ times as big as a conventional gas light.

MINNEAPOLIS GAS COMPANY'S massive No. 2 gas holder, long a landmark in northeast Minneapolis, is now sharing honors with a new company landmark — *the biggest gas light in the world.*

When the 3,000,000 cu ft four-lift holder is razed next year, Minnegasco's giant lamp will hold the spotlight alone at the busy corner of Broadway and Tyler streets.

The 28-ft high light with a 1300-lb, 78-mantle burner head was placed in service in mid-June alongside a company billboard that sets in front of the 50-year-old holder. It has been named the *Aquatennial Gas Light* in honor of the Minneapolis Aquatennial, the city's famous summer festival.

Thousands of motorists and pedestrians daily see the big light adding friendly, eye-catching emphasis to the billboard's message, *"Go first class . . . light with gas!"*

The light was dedicated on June 16 by Queen of the Lakes, Gail Nygaard. Other members of Aquatennial officialdom, gas company officials and a representative of the Minneapolis City Council joined in the lamp lighting ceremony. Queen Gail, wearing the tiara of her office and clad in a white, full-skirted formal, ascended the platform of a hoist and was elevated to the gas light's 10-ft high burner head.

At the wave of Miss Nygaard's "wand," the Aquatennial Gas Light leaped to its full, dazzling 13,000 candlepower brightness and officially joined the gas sales promotion roster.

Idea for the big light was born early in 1960 as the joint brainchild of Minneapolis Gas and its agency, Knox Reeves Advertising, Inc. R. F. Calrow, assistant vice president in charge of advertising, sales promotion and public information, brought the idea to research vice president, M. K. Patterson.

Patterson huddled with utilization engineer, Thomas C. Carson, and master sheet metal worker, Bernhard O. Gagnelius. As far as the trio could determine, nothing like this had been built before and no blueprints or plans were available. They started from scratch and committed the project to paper.

It was decided that the linear measurement would be 8¼ times the size of a popular model of outdoor gas light. The final product was a burner head 10 ft, 9⅝ in. high. Volume measurement is more than 600 times that of the conventional outdoor lamp.

The task of fabricating the light went to Gagnelius, a bespectacled veteran who can do anything with metal. From his shop he assembled the main ingredients of the light — 94 ft of ⅛ by 2-in. iron band, 58 ft of 2 by 2 by ⅛-in. angle iron, 132 sq ft of 16 gage common iron, and 13 sq ft of ¼-in. boiler plate.

One of the trickiest parts of Gagnelius' work was keeping the iron perfectly straight. Because iron bends when welded, it was necessary to heat and hammer the sections so there would be no stress on the glass.

Each of the four glass panels measures 63-in. across the top, 34-in. across the bottom, and is 65-in. in height. Weight of each of the ¼-in. heat treated panes, similar to glass used in fireplace fire screens, is 85 lb. They are cushioned in their channels by asbestos insulation.

The sleeve on the bottom plate presented another problem. A section of 12-in. pipe was slit, heated and bent to make room for a piece 2¾-in. wide, which was welded into place. This enlarged pipe then slipped comfortably over the 12-in. pipe section used as the lamp post. It was secured for extra safety with six set screws and then welded.

Patterson and Carson designed the lighting column. Initially, they thought in terms of one huge mantle but finally decided to use a stainless steel manifold because of its great resistance to heat and corrosion.

Attached to the standard stainless steel pipe are 78 pieces of stainless steel tubing, bent down at right angles to hold Coleman mantles. There are six tiers of seven mantles each and six tiers of six mantles each.

The post of the light is a 25-ft length of 12-in. gas main pipe, seven feet of which are anchored in a ton of concrete.

Gas is fed to the light through ⅜-in. copper tubing that is secured to the post by clamps. It is tied into the company's class II system, which includes lines with pressures not exceeding 25 psig, and operates on 4 psig. (Normal residential pressure is approximately 0.25 psi.) Pressure of 4 psi produces maximum incandescence from the mantles. Gas consumption of the giant light is 148 cu ft per hour, approximately equal to the input of two residential heating plants.

The Aquatennial gas light is still considered somewhat in the experimental stage. It has not yet been subjected to an onslaught of the elements and after a year's observation of performance some changes may be necessary.

Cost of materials for the Aquatennial Gas Light was less than $1300, including $563 for the stainless steel mantle tower, $296 for the glass, and $271 for the metal parts of the burner head.

Already the big light has attracted the attention of promotion-minded business establishments. At least two concerns have seriously inquired about the possibility of having giant gas lights at their locations.

Meanwhile, northeast Minneapolis' new landmark, the biggest gas light in the world, continues to beam out its 13,000 candlepower sales message around the clock . . . *"Go First Class . . . With Gas!"*

AQUIFERS for Underground Natural Gas Storage

4 | *Individual well performance; hydraulics; reservoir performance*

Joseph A. Kornfeld, *Natural Gas Consultant, Tulsa, Oklahoma*

Individual Well Performance

Individual well behavior is discussed with correlations of bottom-hole conditions observed in the case of *ordinary tubed well* with that of a gravel wall well. (Production and operating characteristics of these two types of wells are shown on page below.)

Ordinary tubed well. In this case, the size of the screen opening is very fine to reduce the movement of fine sandstone into the well casing.

Inevitably, sand cutting will occur and will destroy the screen in time. Under these conditions, drawdown will be excessive and will result in a low specific producing capacity. As a result, horsepower lifting requirements will be great and therefore pumping costs will tend to rise to an excessive level.

Moreover, if a screen that employs larger or coarser screen opening size is used, the fine sand particles will enter the well casing together with the water, resulting in the formation of cavities within the aquifer itself and eventually caving with possible destruction of the well. In this case, the *effective screening diameter* is the actual diameter of the screen.

Gravel wall well. In this case, with the screen employed to support the gravel wall only, the screen, therefore, uses relatively large openings with result low values of inlet velocity and entrance friction.

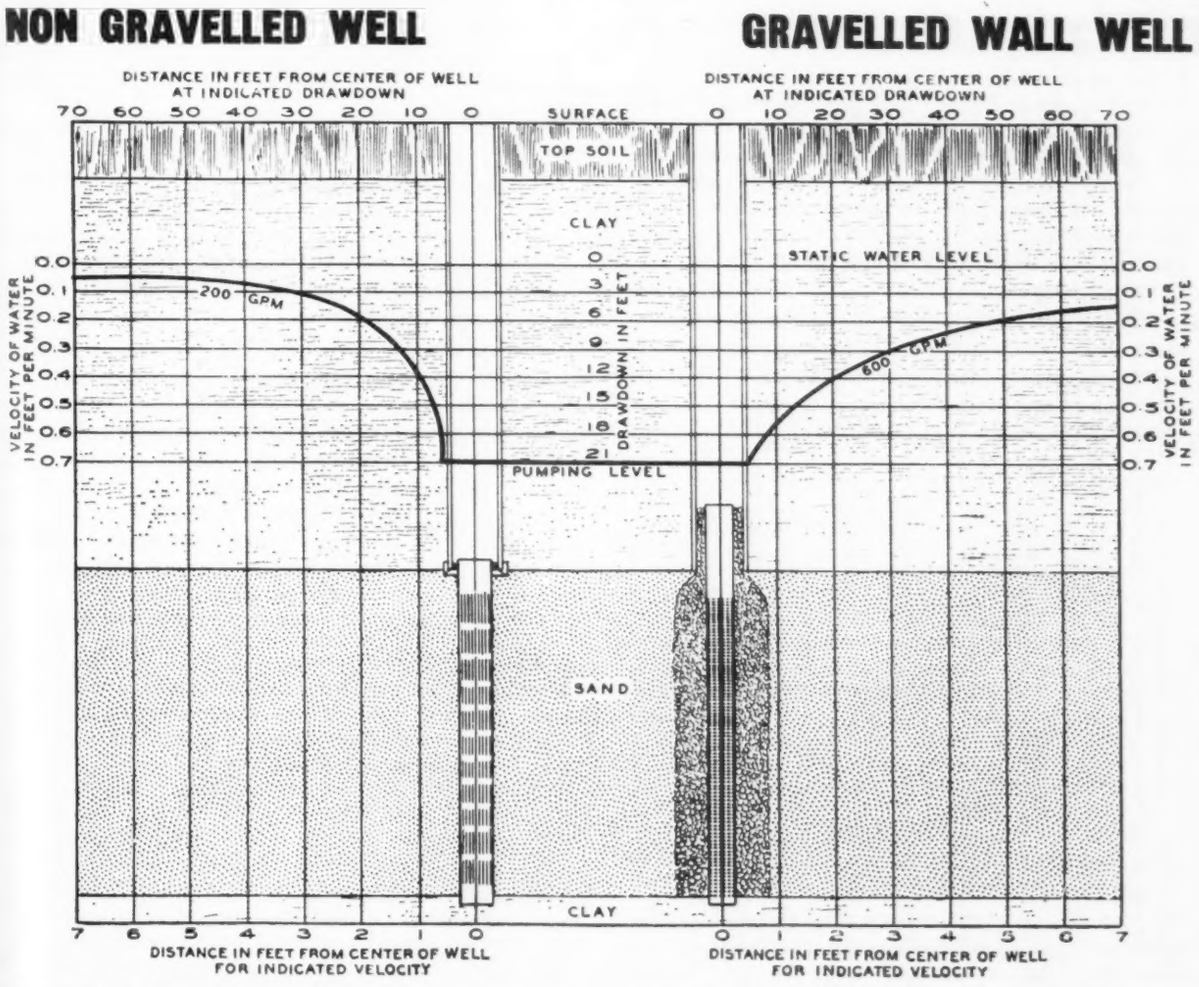

NON GRAVELLED WELL
GRAVELLED WALL WELL
DISTANCE IN FEET FROM CENTER OF WELL AT INDICATED DRAWDOWN
70 60 50 40 30 20 10 0
SURFACE
TOP SOIL
CLAY
STATIC WATER LEVEL
200 GPM
600 GPM
DRAWDOWN IN FEET
0 3 6 9 12 15 18 21
PUMPING LEVEL
VELOCITY OF WATER IN FEET PER MINUTE
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
SAND
CLAY
DISTANCE IN FEET FROM CENTER OF WELL FOR INDICATED VELOCITY
7 6 5 4 3 2 1 0
0 1 2 3 4 5 6 7

FIG. 1. **Production and operating characteristics** of two types of water well completions. An underreamed gravel wall well equipped with shutter screen is shown at right. At left is a standard tubed, non-gravelled wall with usual water well strainer installed in direct contact with the water-bearing sands. (Courtesy Layne-New York Company.)

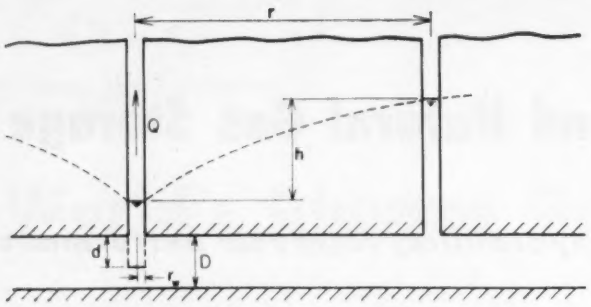


FIG. 2. **Drawdown curve** for a partially penetrating well. (Fig. 2, 3, 4, and 5 courtesy of American Geophysical Union.)

Water is able to pass freely from the aquifer through the gravel wall into the relatively large screen openings with no serious disturbance to the native aquifer. Under these bore-hole conditions, drawdown is moderate and specific producing capacity is high. Therefore, the pumping head is low, and lifting costs remain moderate.

Despite the fact that relatively large screen diameter has been selected and utilized in this case, sand movement has been restrained by the thick gravel wall. Sand cutting at the point of screen openings is at a minimum due to low inlet velocity values and reduced entrance friction, all of which tends to result in a long-lived bottom-hole installation.

In this case, the *effective screening diameter* is the diameter of the gravel wall and not the diameter of the screen.

Well maintenance. Well failures may be caused by any or a combination of the following factors:

1. Lowering of the water table.
2. Incomplete penetration of the aquifer by the well-bore.
3. Collapse or clogging of the screen setting.
4. Chemical clogging of the sandstone or crevices that feed water from the aquifer into the well, caused by precipitates from base-exchange reactions from recharge waters.
5. Leaks in the tubing.
6. A worn well pump.
7. Overpumping of the aquifer.

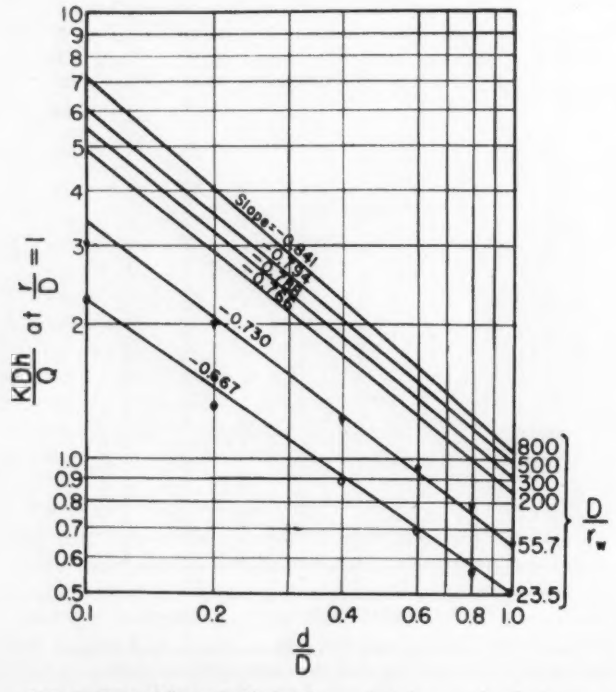


FIG. 3. **Graphic relationship** on log-log scales between KDh/Q at r=D and d/D.

The basic problem of the lowering of the ground-water table is related to the factors of

(a) specific yield
(b) permeability
(c) incomplete penetration of the aquifer
(d) well spacing
(e) number of wells completed in the aquifer.

It may be found necessary to deepen existing wells, drill additional wells into the aquifer, either by infilling or extension, and/or individual well stimulation by surging, shooting, acidizing, or chlorinating operations.

Effect of Penetration

Li, Bock, and Benton, in their electrical model analogy between the flow of electricity and the flow of fluids through porous media, have approached experimentally the relationship between *drawdown* and *yield* in an aquifer due to pumping from a *partially-penetrating well.*

They found that, except for a small area near the well, the drawdown curve of a partially penetrating well has the same shape as that of a fully-penetrating well. Outside of

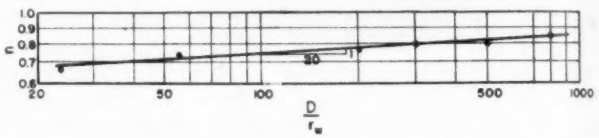


FIG. 4. **Graphic value** on log-log scales of "n" in Equation 5, plotted vs. D/r_w.

this small area near the well bore, however, the two drawdown curves *differ by a constant magnitude* that can be found from a simple empirical formula obtained from the experimental data.

(Reference is made to the drawdown curve for a partially-penetrating well shown in Fig. 2.)

Example: Fully-Penetrating Well. When the well penetrates the whole thickness of the well, the flow is relatively simple. Under conditions of isotropic and homogeneous lithology and uniform thickness, the flow into a *fully-penetrating well* is radial and the drawdown of the piezometric surface can be found from

$$\frac{dh}{dr} = \frac{Q}{2\pi KDr} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where: K = coefficient of permeability (dimensionally, length per unit time)
d = depth of penetration, ft
D = total thickness of aquifer, ft
Q = discharge for full penetration, gal per day
h = drawdown, ft
r = external radius, ft
r_w = internal radius of bore-hole, ft

Example: Partially-Penetrating Well. On the other hand, the flow into a partially-penetrating well is certainly much more involved, as the flow conditions in the vicinity of the bore-hole are no longer radial. Kozeny's equation has been used widely in practice.

$$Q = \frac{2\pi Khd}{\log_e (r_e/r_w)} \left(1 + 7\sqrt{\frac{r_w}{2d}} \cos \frac{\pi d}{2D}\right) \quad . \quad . \quad (2)$$

Despite the reasonable results attained in practice, application of Kozeny's formula finds certain limitations. Since the flow is essentially radial beyond a certain distance from the well, a formula for partially-penetrating wells should satisfy Equation 1. for *large values of r.* This is not true of Kozeny's formula.

In the model study the idealized aquifer chosen was described as follows:

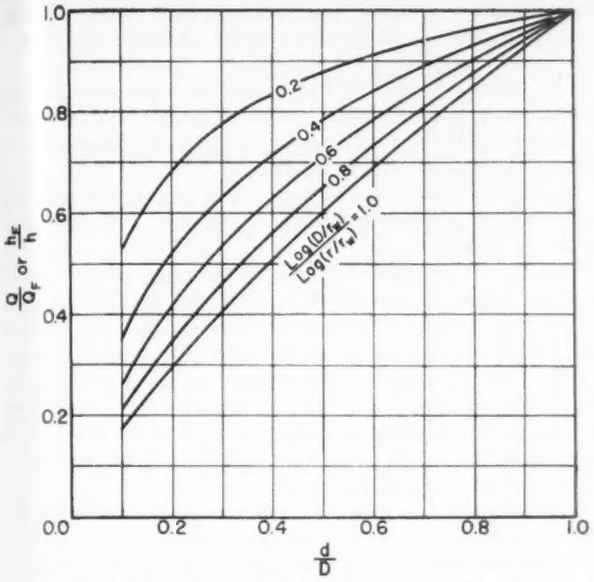


FIG. 5. **Graphic relationship** between partial penetration and corresponding discharge of well in an aquifer.

1. The aquifer is horizontal and of uniform thickness;
2. The aquifer is composed of isotropic and homogeneous material;
3. There is no flow across the interfaces between the aquifer and the aquicludes;
4. The aquifer is of sufficient areal extent so that the effects of boundaries can be neglected; and
5. *Steady-state conditions* are established over a large area around the well.

The problem reduces itself to finding the relationship between the draw-down and discharge in an *axial-symmetrical steady-state flow system*. Not considered in the present study are energy losses through the well-screen and friction losses in the well itself.

Although the hydraulic head within the aquifer is distributed in three dimensions, the distance h is defined as a function only of the radial distance from the well. As shown in the illustration, this quantity is the difference in hydraulic head between an arbitrary point at the top of the aquifer and another point at the well. The difference in head $h\,(r)$ is thus uniquely determined by the drawdown in the piezometric surface indicated by a test well just penetrating the top of the aquifer. The problem then is to determine the relationship between the shape of this *piezometric surface*, the *discharge*, and the *degree of penetration* of the well.

Assuming that the flow follows Darcy's Law, it can be

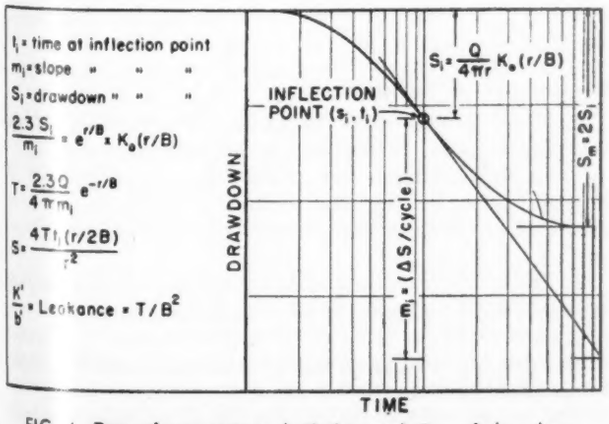

t_i = time at inflection point
m_i = slope " " "
S_i = drawdown " " "
2.3 S_i / m_i = e^{r/B} x K_o(r/B)
T = 2.3Q / 4π m_i e^{-r/B}
S = 4T t_i (r/2B) / t^2
K'/b' = Leakance = T/B^2
INFLECTION POINT (s_i, t_i)
S_i = Q/4πT K_o(r/B)
S_m = 2S_i
DRAWDOWN
E_i = (ΔS/cycle)
TIME

FIG. 6. **Drawdown curve** depicting variation of drawdown with time due to a steadily-discharging well from an infinite leaky aquifer.

shown by dimensional analysis that this is equivalent to determination of the explicit functional relationship:

$$\frac{KDh}{Q} = f\left(\frac{D}{d} \times \frac{r}{r_w} \times \frac{D}{r_w}\right) . \quad . \quad . \quad . \quad (3)$$

By means of the analogy between the flow of electricity and seepage through porous media, the function expressed above may be obtained empirically by using a geometrically similar electrical model.

The authors obtained a simple empirical formula for the relationship between drawdown and yield as follows:

$$\frac{KDh}{Q} = \frac{1}{2\pi} \log_e\left(\frac{r}{r_w}\right) + \frac{1}{2\pi}\left[\left(\frac{D}{d}\right)^n - 1\right] \log_e\left(\frac{D}{r_w}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

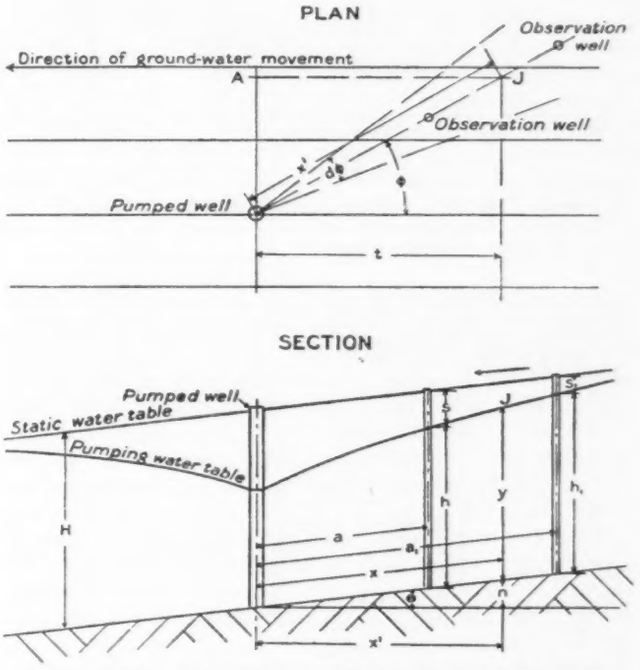


FIG. 7. **Plan and section of ideal ground-water conditions** assumed by G. Thiem in determining of permeability of water-bearing materials for the derivation of specified yield. (Fig. 6, 7, 8, and 9 courtesy of U.S.G.S.)

To evaluate the exponent n, a curve showing the relationship of n to $\frac{D}{r_w}$ is plotted in an accompanying figure on log-log scales. From the graph

$$n = \frac{3}{4}\left(\frac{D}{100\, r_w}\right)^{.05} \cong \frac{3}{4} . \quad . \quad . \quad . \quad (5)$$

Let Q and Q_F be the discharge for partial penetration, and full penetration of the same aquifer respectively for the same drawdown, respectively. To show the effect of partial penetration on the discharge, Equation 4 can be modified as follows:

$$\frac{Q_F}{Q} = 1 + \frac{\log D - \log r_w}{\log r - \log r_w}\left[\left(\frac{D}{d}\right)^n - 1\right] . \quad . \quad (6)$$

This expression is also represented by the figure entitled "Graphic relationship between partial penetration and corresponding discharge in an aquifer."

The two most essential individual well performance curves are:

1. The drawdown curve and
2. The recovery or buildup curve.

Drawdown curve. A very important curve is the "drawdown curve," which is defined as a continuous curve that

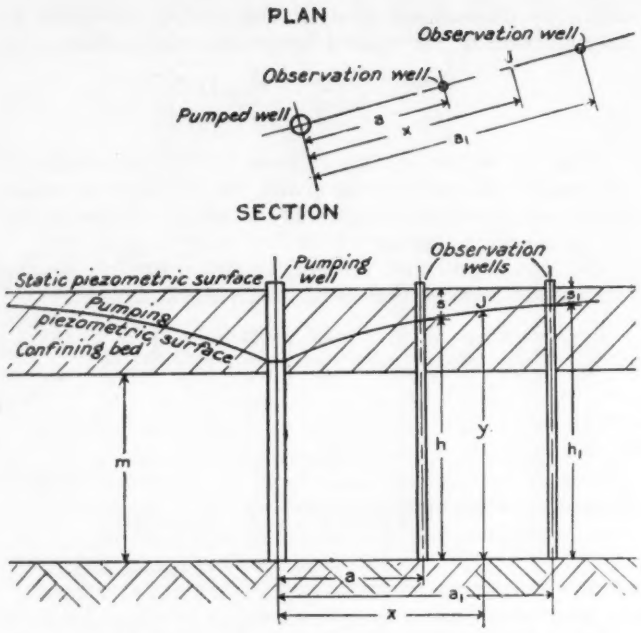


FIG. 8. **Plan and section** showing assumed ground-water conditions from horizontal artesian conditions for Wenzel's modification of the Thiem formula.

represents the decline of the water-level in a well during the period of pumping from the aquifer. The curve is plotted on rectangular coordinates. On the X – X′ axis, time is plotted, either in actual time measurement in hours, or in elapsed time, from the commencement of pumping. The drawdown is plotted on the Y – Y′ axis, either in actual elevation above or below sea level, or in the number of feet below the original elevation which prevailed before pumping started.

To obtain the drawdown of the water table at a given time, it is necessary only to subtract the depth from the surface to the water level that prevailed before pumping started, from the depth to the depressed water level at that given time.

Moreover, the subsurface elevation of the depressed water level can be obtained by subtracting the drawdown at a given time from the altitude of the static or equilibrium level.

Recovery or build-up curve. A recovery or build-up curve is a continuous curve that represents the movement of the water level in an observation well after pumping has stopped. The curve is plotted on rectangular coordinates. On the X – X′ axis, time is plotted either in actual time measurement or in elapsed time from the moment pumping stopped. On the Y – Y′ axis *recovery* is plotted either in feet above the assumed zero or in actual elevation above or below sea level.

Recovery curves exhibit generally smoother appearance than draw-down curves due to the absence of irregularities which are caused by variations in the pumping rate or by interruptions in pumping.

The recovery curves will show that in observation wells situated close to the pumping well, the recovery was most rapid immediately after pumping stopped, whereas in those observation wells situated relatively far from the pumped well, the recovery was most rapid several hours after pumping stopped. Wenzel explains that rate of recovery from the water table is generally *inversely proportional* to the distance from the pumped well. This is true, however, only for a short time after pumping ceases.

Cone of Depression

The cone of depression is the graphic representation of the water table around a pumped well — a form that is assumed after pumping commences. This form is comparable to that of an inverted cone, although it is not a true conical projection.

Where the lithology of the aquifer is homogeneous, the cone of depression will be circular if the initial water table is horizontal. If the initial water table slopes, however, the cone of depression will be elliptical.

The form of the cone of depression at a given time can be portrayed graphically either by profiles or contours of the water table.

The rate at which the radius of the cone of depression develops depends considerably upon the specific yield of the aquifer. Most of the water discharged by the pumped well during the first hours of the pumping period is taken directly from the aquifer immediately adjacent to the borehole of the pumped well. The amount of water taken from storage in this manner is indicated by the draw-down of the water table which provides a method for determination of the specific yield of the aquifer.

If the aquifer has a low specific yield, the radius of the cone of depression will possibly develop more rapidly than if the aquifer exhibited a high specific yield. This may be explained by the fact that if the specific yield is low, less water is available for transmission in the aquifer and there the effect of pumping will be transmitted outwardly from the pumped well at a higher rate.

The actual difference in the rate at which the radius of the *cone of depression* will develop in aquifers exhibiting different specific yields, will depend on the relationship which exists between the *specific yield* and the *permeability* of the aquifer.

Significance of cone of depression: Theim observes that the hydraulic system in an aquifer is in balance; the discharge is equal to the recharge and the water table or other piezometric surface is more or less fixed in position. Discharge by wells is a new discharge superimposed upon the previous system.

Before a new equilibrium can be established, water levels must fall throughout the aquifer to an extent sufficient to *reduce the natural discharge* or *increase the recharge* by an amount equal to the amount discharged by the well.

Until this new equilibrium is established, water must be withdrawn from storage in the aquifer. Conversely, the new equilibrium cannot be established until an amount of water is withdrawn from storage by the well sufficient to depress the piezometric surface to an extent to change the recharge or natural discharge the proper amount. The depression of the piezometric surface is called the *cone of depression.*

In analyzing the characteristics of the cone of depression in an idealized aquifer of *infinite area extent,* time is an essential variable in the mathematical description of this cone. The time rate of lateral growth of the cone is independent of the rate of discharge by the well and depends only upon the physical characteristics of the aquifer.

Recharge of Formation

Artificial ground-water recharge. The methods of increasing recharge are described by Meinzer as of two kinds:

1. *Indirect methods,* in which increased recharge is brought about by locating production wells as close as practicable to areas of rejected recharge or natural discharge, and

2. *Direct methods,* in which water from surface sources is conveyed to points from which it percolates into a body of ground water. In turn, the direct methods can be further subdivided into two groups (a) recharge by surface application and (b) recharge through wells.

The success of any project for direct recharge depends upon the unit cost of putting the water into storage, which is determined largely by the rate at which recharge can be

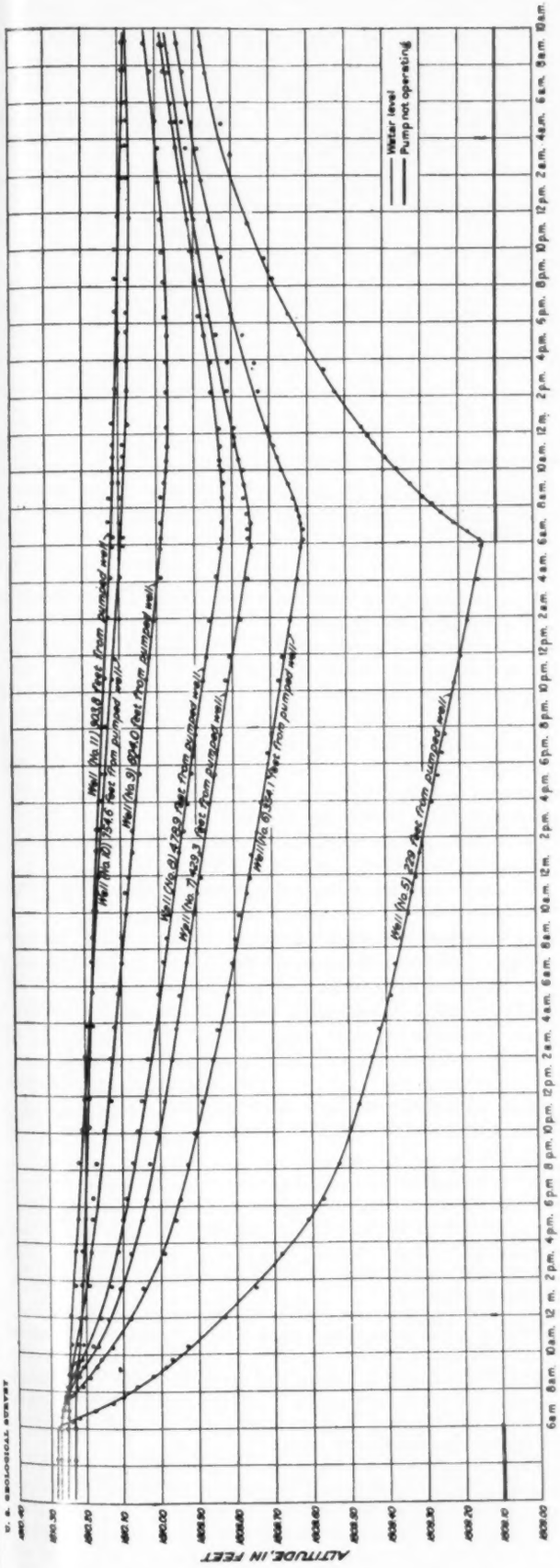

Water level
Pump not operating
Well No. 11 2018 feet from pumped well
Well No. 10 734.6 feet from pumped well
Well No. 9 1824.0 feet from pumped well
Well No. 8 1429.9 feet from pumped well
Well No. 7 1429.3 feet from pumped well
Well No. 6 1341 feet from pumped well
Well No. 5 1229 feet from pumped well
ALTITUDE IN FEET
6am 8am 10am 12 m. 2pm. 4pm. 6pm 8 pm. 10pm. 12pm. 2a.m. 4am. 6am. 8am. 10am 12m. 2pm. 4pm. 6pm. 8pm. 10pm. 12pm. 2a.m. 4a.m. 6a.m. 8a.m. 10a.m. 12m. 2p.m. 4p.m. 6p.m. 8p.m. 10p.m. 12p.m. 2a.m. 4a.m. 6a.m. 8a.m.

FIG. 9. **Typical draw-down and recovery curves** for a group of observation wells located in a radius of less than 1000 ft of a pumped well.

accomplished. In turn, the rate is controlled largely by the permeability of the material through which the recharging water must percolate and the amount of clogging which is produced by the water. *In all projects, the problem of clogging must be taken into consideration and, therefore, water must be as clean as possible and chemically compatible so as not to produce harmful precipitates.*

Geological structure and recharge. The determination of the actual intake area and of its actual recharge capacity may constitute a complex problem that will require intensive geological and hydrological study before the practicability of artificial recharge can be determined. Thus, water applied for artificial recharging may seep rapidly down to a water table, but the ground water may be perched over an impervious bed that returns it to the surface nearby or conducts it into deposits which lie above the confining bed of the producing aquifer.

Artificial Recharge. Usually, water produced from the aquifer is utilized to displace storage gas from the crest of the anticline. If, however, foreign recharge water is introduced directly into granular aquifers through wells, chemical reactions may occur among solutes in the water and minerals in the aquifer that can alter the quality of the water. Precipitates also may form, plugging the recharge well, and possibly affecting the *transmissibility* of a considerable part of the aquifer.

It is desirable to correlate the Eh, pH, and sodium percentages of the native ground water and the recharge water in prediction of the chemical compatibility of underground waters. Using these and other values obtained from chemical analyses, graphs of calculations show the probable behavior of ferric hydroxide and calcium carbonate, (the *main potential sources* of troubles from precipitates), over a wide range of operating conditions.

Water-spreading and other techniques, which provide for recharge through natural channels in the rock and soil, involve fewer potential chemical problems.

Chemical compatibilities between the native water within the aquifer and that of recharge water must be considered seriously if the underground natural-gas storage project is to remain operable on a permanent basis over a considerable portion of the aquifer within the *higher structural contours* of the anticline, where gas is stored and withdrawn.

Specific Yield

Remson and Lang define the specific yield of a water table aquifer as one measure of the amount of water within the aquifer that is available for recovery (development). It is expressed as a percentage or decimal fraction of the total volume of material of which the aquifer is composed.

The specific yield may be determined during the course of an equilibrium pumping test by comparing the volume of dewatered material in the *cone of depression* with the total volume of discharge water.

Long-term safe yield. The long-term safe yield of a group of wells is limited by the influent seepage supplying the aquifer that is penetrated by the wells. McGuinness defines the safe yield of a ground water development as "the rate at which water can be withdrawn for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible."

The *safe yield* is not a fixed quantity for a given aquifer, but is dependent upon the specific yield, the permeability, the lithology and permeability barriers, the number of wells which penetrate the aquifer, and the average well spacing.

Pumping operations which exceed the *safe yield point are* called *overpumping* or *overdraft*.

These conditions must be taken into consideration before the characteristics of the aquifer are sufficiently well understood to justify its conversion to underground natural-gas storage service.

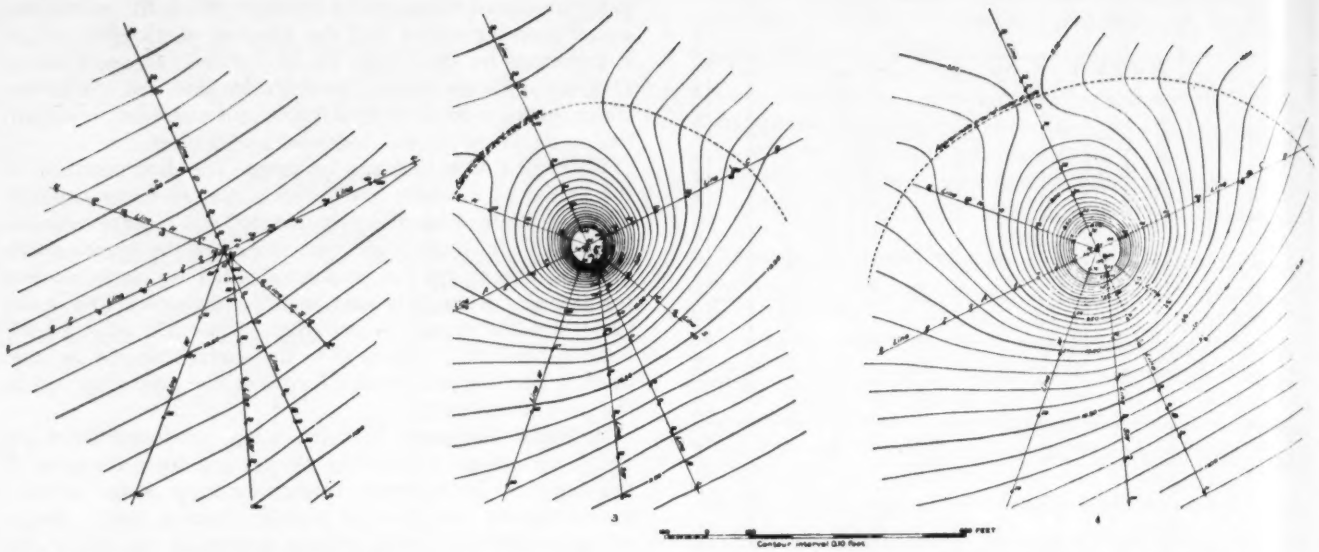


FIG. 10. **Cone of depression** is indicated in above figures, which depict drawdown conditions around a pumped well. Contours are mapped on top of the water table before pumping (plan at left) and at several times after pumping began. Plan at center shows conditions at end of sixth hour. Plan at right shows conditions existing at end of 48th hour after pumping began.

Nomenclature

Piezometric surface: the imaginary surface to which the water rises under its full head.

Specific yield: the ratio of the volume of water which, after being saturated, will yield by gravity to its own volume.

Draw-down curve: a continuous curve representing the decline of the water level in a well during the period of pumping.

Recovery (or build-up) curve: a continuous curve representing the movement of the water level in an observation well after pumping has ceased.

Cone of depression: the graphic representation, either by profiles or contours of the water table, of the water table around a pumped well which form is assumed after pumping commences. Under homogeneous lithology of the aquifer rock, the outline of the cone of depression will be *circular* if the water table is *horizontal;* but if the initial water table *slopes,* the form will be *elliptical.*

Zone of saturation: that layer of rock in which the interstices are filled with water under hydrostatic pressure.

Zone of aeration: the combined interval from the surface of the earth down to the top of the zone of saturation, subdivided into the belt of soil water, the capillary fringe, and the intermediate belt.

Belt of soil water: that part of the earth's crust which lies immediately below the surface from which water is discharged into the atmosphere in perceptible quantities by evaporation from the soil or transpiration from plants: its thickness is limited by the character of the vegetation and the soil texture.

Capillary fringe: the belt that overlies the *zone of saturation* and contains interstices, some or all of which contain water that is continuous with the *zone of saturation,* but is held above that zone by capillary action against the forces of gravity.

Intermediate belt: the residual part of the zone of aeration; is absent when the belt of soil moisture joins the *capillary fringe.*

Coefficient of storage: for water-table conditions, is slightly but negligibly higher than the specific yield because it includes the small amounts of water derived from storage by compaction of the beds and expansion of the water in the zone below the water table as the water table declines.

Specific yield: the quantity of water yielded by gravity drainage from saturated water-bearing material expressed as a percentage or a decimal fraction of the total volume of the material drained.

Coefficient of permeability: a measure of the capacity of a water-bearing material to transmit water. The unit of measurement commonly used for permeability is the "Meinzer unit" or simply the "meinzer," defined as the rate of flow in gallons per day through a cross-sectional area of one square foot under a hydraulic gradient of one foot per mile at a temperature of 60 F. In actual field practice, however, it is customary to use a similar unit of measurement that is based on the prevailing water temperature with no correction to the standard temperature of 60 F. Coefficients of permeability range from 0.005 for clay to more than 20,000.0 for sand and gravel.

Coefficient of transmissibility: a measure of the analogous property of an aquifer as a whole: it is the volume in gallons per day through a vertical strip of the aquifer one foot wide and extending through the entire height of the aquifer at unit hydraulic gradient, measured at field temperature with no correction to the standard temperature of 60 F.

Safe yield: the rate at which water can be withdrawn from an aquifer without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible.

EDITOR'S NOTE: This installment is the fourth in a series of five engineering articles on "Underground Natural Gas Storage in Aquifers" being presented each month as part of AGJ's continuing educational-refresher series on natural gas and gas distribution operations.

The first installment *(April 1960)* analyzed the need for gas storage, types of storage, and the history of aquifers. The second installment *(May 1960)* covered criteria employed for selection of aquifers, geology, lithology, and economics. The third installment *(June 1960)* covered lease rights acquisition, the drilling contract, well spacing, drilling, logging and completion of input, output, and service facility wells.

This installment discusses individual well performance, principles of hydraulics, and reservoir performance of aquifers selected for underground natural gas storage. Basic formulas are presented with reference to the analysis of reservoir performance of the aquifer in which the artificial bubble of natural gas will be introduced for input and output service.

The final installment, to appear in the September 1960 issue, will analyze well stimulation methods, and the use of radioactive tracers. A comprehensive, selected bibliography, arranged by topics, will accompany that installment.

Six Safety Suggestions

Stimulating interest in safety is a never ending task . . .
Here are six ways to keep interest alive in your company.

H. E. Carroll

ACCIDENTS, as gas company executives know, cost money. In addition to the out-of-pocket expense for medical treatment and equipment repairs, there are many other hidden costs — lost time, higher insurance premiums, overhead, lower morale, and the executive time spent in investigation.

Safety programs provide an answer. If interest of the employees is kept at a high level, safety programs can go a long way in reducing the accident rate in your gas company. Here are six ideas to spark your safety program:

√ Daily Safety Report

Paper work does not make safe work. But, the daily safety report does have value in keeping the accident rate at a low level. Mentioning safety once a week or once a month doesn't build a strong impression. But, when there is a daily or a twice a day reminder of safety, the message is driven home to the employees and the supervisors.

You may find that the daily safety report will give your safety program a new lift. One plan is to have the report completed at the end of each shift. It reports any accidents (however minor) and lists any unsafe conditions or makes any safety suggestions that come up.

Another daily report idea is to have a two part report. The first part is completed after a safety inspection at the start of the shift. The second part of the report is the results of the shift's activity in safe practices.

In addition to keeping your employees and supervisors more safety conscious, the daily report can bring forth some warnings of unsafe conditions and valuable suggestions for your safety program.

√ Safety Ads

Management may find this a valuable idea to spark the safety program. It not only reaches present employees, but prospective employees and the general public. It reminds your employees of safety and announces to everyone that your gas company is a safe place to work.

Briefly, this plan takes small space in your local newspaper each day. One column by one inch is enough space to tell your safety story. Copy for the ad tells how many days your gas company has gone without an accident. Naturally, the copy needs to be changed each day. You can usually make a deal with your local newspaper to change the number each day unless notified that you have had an accident.

√ Safety Jury

Gas company management can make the employees feel they are part of the act in the safety program when they have something to do. The *safety jury* is one way to keep everyone safety conscious and to handle safety problems in a fair and just manner.

This jury is selected from the employees of the gas company either by management or by the employees. They serve for a month, six months, or a year depending on the plan established. Whenever there is an accident the safety jury listens to the evidence in the case and makes a decision — carelessness or the need for safer equipment or a change in rules.

Another function of the safety jury is to pass on all safety equipment purchased. Also, they help establish the safety rules for the company and set up procedure for handling accident cases or unsafe practices.

Some executives feel that it is best to have one or more members of the management team on the safety jury. Others feel that it accomplishes more when the employees select and participate on the jury themselves.

√ Home Safety

Encouraging home safety may seem like a left-handed approach to company safety. It does, however, accomplish the main purpose of any safety program — keeping everyone safety conscious.

Gas companies that encourage home safety provide various types of booklets and pamphlets. These are either mailed to the employee's home or distributed on the job to take home. This gives the employee's family a feeling that the company is interested in the welfare of its employees . . . and since they are so concerned about home

safety they realize that the work on the job is made as safe as possible.

Local chapters of the Green Cross have booklets and other material that can provide plenty of fuel for the fire of home safety. And, in most cases you will find them more than willing to help you organize a program to encourage home safety.

√ Safety Awards

Recognition is one of the strongest motivating powers for anything. Accident elimination can be improved when there is some form of recognition for safe workers in your company.

One of the most obvious methods is to give safety cups or pins indicating the number of years the employee has gone without an accident. These awards are relatively inexpensive and the cost is very small when compared with the cost of accidents or higher insurance premiums in your gas company.

Another plan is to post the photo of each employee on the company bulletin board as he passes a certain landmark in safe service. For instance, when an employee has been in your employ a year without an accident, his photo is posted on a bulletin board for a week.

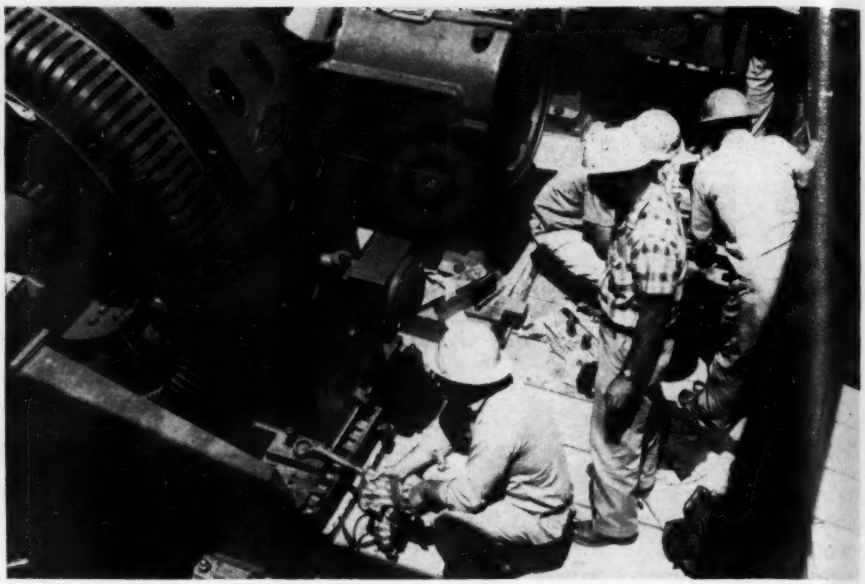
When this same employee passes the second year mark, his photo (or a new one) is again posted in the Safety Hall of Fame. A variation of this photo recognition idea is to keep the photo on display as long as the employee continues to observe safe practices.

√ Safety Publicity

Another way to keep everyone conscious of safety is to give your safety program local publicity. This idea can be incorporated with some of the other ideas or used separately. For example, each time you distribute some home safety information, you can give the story to your local newspaper. This will cause interest to increase at all levels for the news in the home safety program.

When your safety jury is selected, the news of this can be given publicity in your local newspaper — names and addresses of your employees serving on the safety jury make news. Or, a feature story about the activities of your safety jury would make interesting reading to local people.

Naturally, every safety award deserves publicity. It is news for the community and added recognition for the employee who has the safety record. Anything and everything your gas company does to promote safety will make good local publicity — and give your safety program an added lift with your employees. * * *



Ready to Whirrr — Technicians install 2000-hp electric compressor at PG&E's McDonald Island gas storage field compressor station. Compressor will be used to inject gas under pressure into the nation's largest storage field.

California Claims Nation's Largest Gas Storage Field

TITLE TO THE NATION'S LARGEST GAS STORAGE FIELD shifts from Illinois to California this November when Pacific Gas and Electric Company puts into operation its McDonald Island storage field, estimated to have a reservoir capacity of 178,500,000 Mcf.

Previous title holder was Peoples Gas Light and Coke Company's storage field at Herscher, Illinois, with 157,000,000 Mcf capacity in two sands — Galesville and Mt. Simon. Now back in third place, is Iowa's Redfield storage area with 140,000,000 Mcf total capacity, also in two reservoirs — St. Peter and Mt. Simon.

The new champion, a nearly-depleted natural gas field acquired by PG&E from Standard Oil Company of California, is located in the San Joaquin River Delta 10 miles northwest of Stockton.

When complete in late 1961, the field will have a working storage capacity of 30,000,000 Mcf of gas and daily deliverability of 400,000 Mcf. A "cushion" of 54,000,000 Mcf will remain in the field to maintain minimum pressure and prevent water intrusion. Initially, however, PG&E will be able to draw out approximately 75,000 Mcf daily — enough for the average winter needs of some 170,000 homes.

McDonald Island field was discovered by Standard Oil in 1936, and gas was produced there seasonally until 1955. In 1958 PG&E acquired the field including 1600 productive acres and 11 existing wells, and later that year began injecting gas into some wells.

2000 Horses Run on Stilts

Now nearing completion at the storage field is a compressor station building to house a 2000-hp electric driven compressor, gas dehydrators and scrubbers, and a 60,000-v. electric substation to power the compressor. The building has been built on a concrete platform 17 ft above ground to protect the compressor and other equipment from flooding should the levees bordering the island fail. Some 137 piles were sunk 60 ft into the sandy soil.

A second compressor at Brentwood Terminal Station, 17 miles west of McDonald, compresses and pushes the gas through an 18-in. line to McDonald Island for further compression and injection into the storage field.

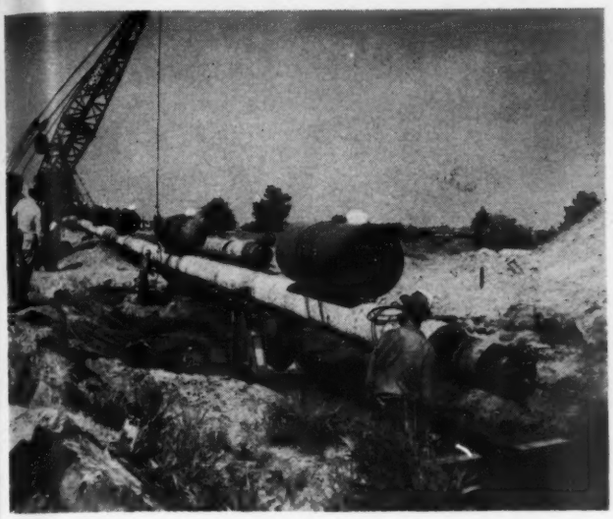
(Michigan Consolidated Gas Company's compressor station at Six Lakes, Michigan, still retains title to the nation's largest storage compressor station with 40,000-hp. See AGJ Apr. 60.)

New wells, being drilled in the field by PG&E, will provide a higher rate of deliverability of the stored gas. Five wells are to be completed in November, another 16 by late 1961, bringing the total to 32 storage wells at the McDonald Island site.

McDonald Island is the second storage field to be developed by PG&E. Last year, it began operating the Pleasant Creek field near Winters, Yolo county, which has a working capacity of 3,250,000 Mcf.

DISTRIBUTION DEVELOPMENTS

NEWS ABOUT CURRENT AND PLANNED CONSTRUCTION



1 **Twin 24-in. gas mains bask in the summer sun** as construction crews ready first section of Brooklyn Union's new Jamaica Bay line for a muddy wade through Paerdegat Basin.

2 **Tight and tense, tractors hold back** on the cables controlling movement of the main. On signal, lines are loosened and the main slides forward on railroad cars to the launching area.

Brooklyn Union's Giant Jamaica Bay Line Wades Paerdegat Basin

Construction of the 1960 portion of Brooklyn Union's giant 30-in. Jamaica Bay line is underway as construction crews of Merritt-Chapman & Scott Corporation cross the Paerdegat Basin in metropolitan New York City with twin 24-in. diameter pipelines. Scheduled for completion in 1961, the Jamaica Bay line is being built in five sections, (AGJ April '60,) and will run through Brooklyn from 86th Street and Colonial Road to a point at Pennsylvania Avenue and Flatlands Avenue in East New York. Ultimately it will extend to the company's franchise boundary at the foot of Rockaway Boulevard in Queens where Long Island Lighting Company will take over and extend the line into its territory.

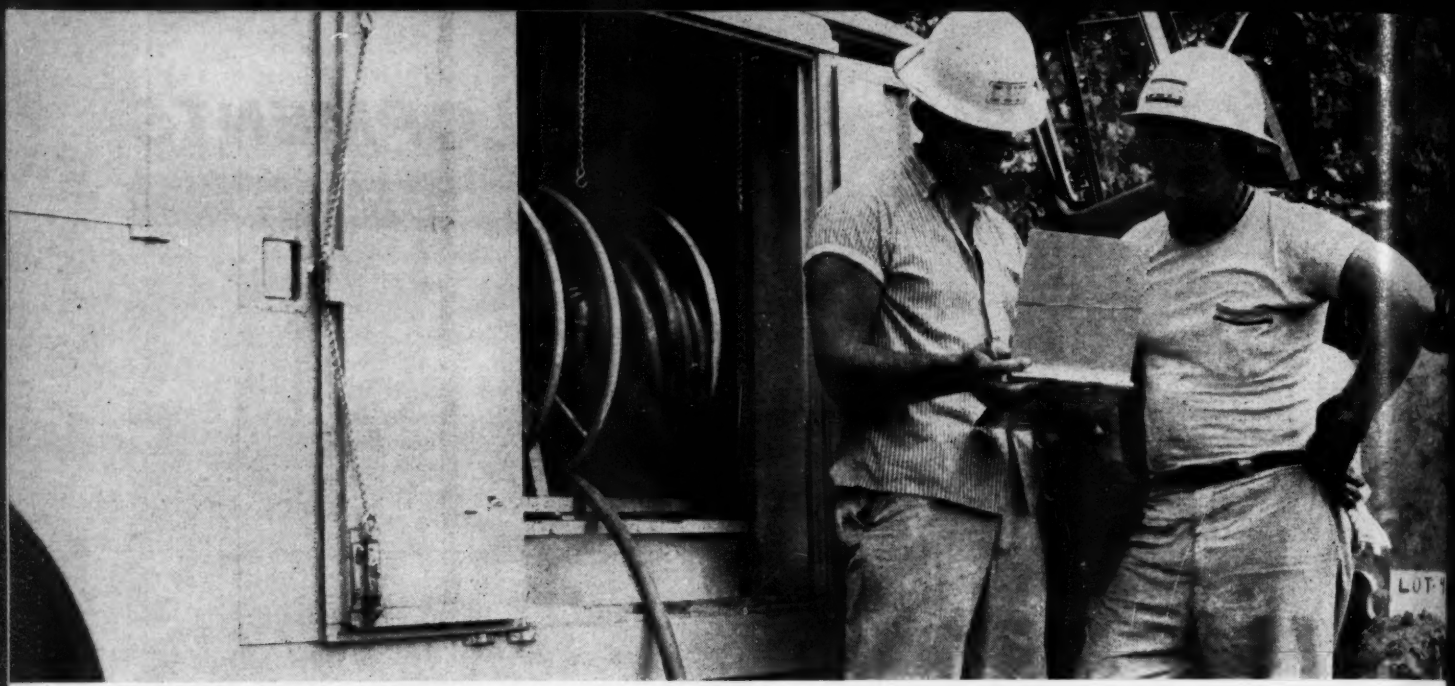
In addition to the Paerdegat Basin crossing, 1960 construction includes approximately 58,580 ft of 30-in., and a 2360 ft spur of 24-in. to connect the 30-in. at Pennsylvania and Flatlands Avenues with the 26-in. at Linden Boulevard and Pennsylvania Avenue.

Late in June contractor crews installed twin 24-in. mains across the Paerdegat Basin, using exactly 2016 ft of cement-coated pipe. Both lines were hydrostatically tested at over 700 psig. Construction of 30-in. headers and 660 ft of 30-in. main completes the Paerdegat Basin contract.

3 **Splash! Into the water nose first.** Pulling cable attached to the nose, guides the pipe into the water.

4 **Bobbing white buoys** mark route of the first main across the still waters of Paerdegat Basin. Second main, foreground, is ready to go.

5 **High and dry on the other side,** welders complete joint of the 30-in. pipe that will merge Y-like with the twin 24-in. lines installed under the Basin.



↑ New England Utility* BOUGHT 1—RE-ORDERED 4 MORE

↓ Eastern Utility* BOUGHT 1—RE-ORDERED 4 MO

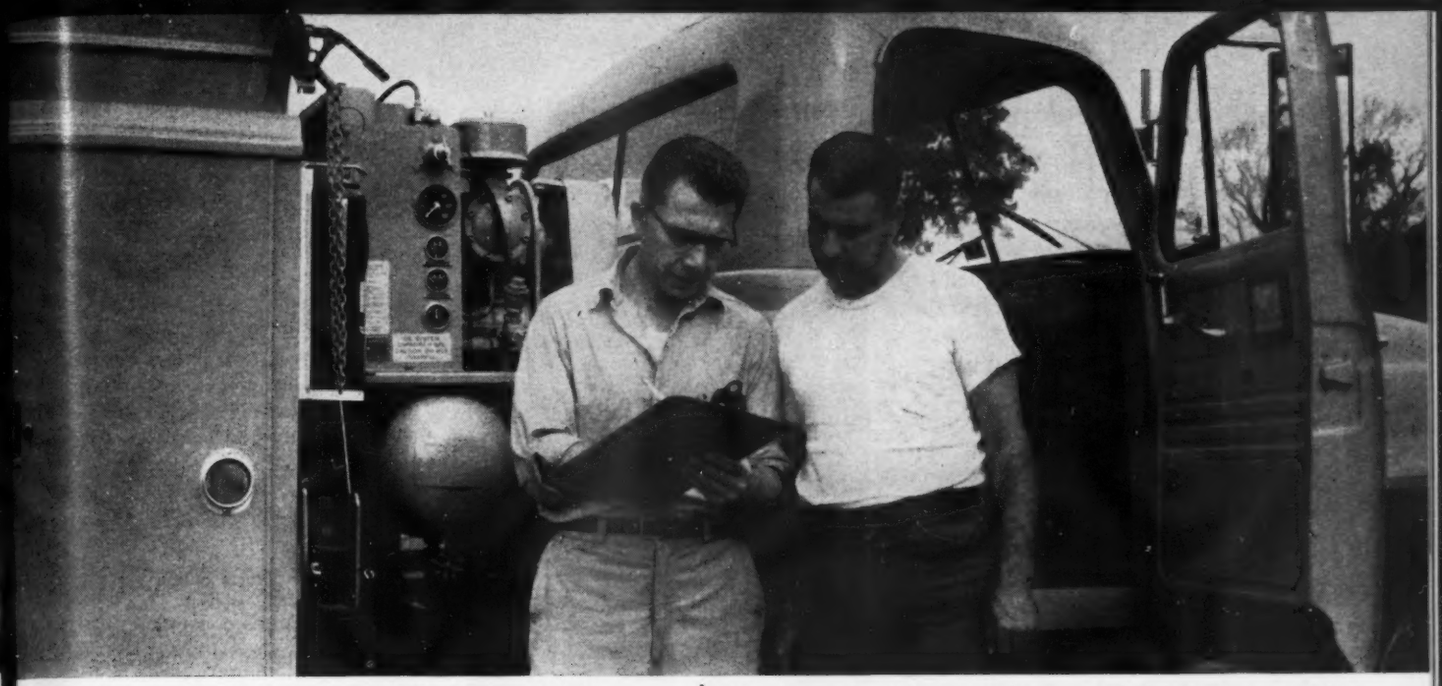
Worthington's Rotary Power Take-Off Compressor...

YOU KNOW IT MUST BE GOOD

Since the Rotary Power Take-Off Compressor was introduced by Worthington in early 1957, many utilities have added it to their fleets. But now, the real results are coming in. After giving the equipment a thorough tryout, the majority of companies are re-ordering.

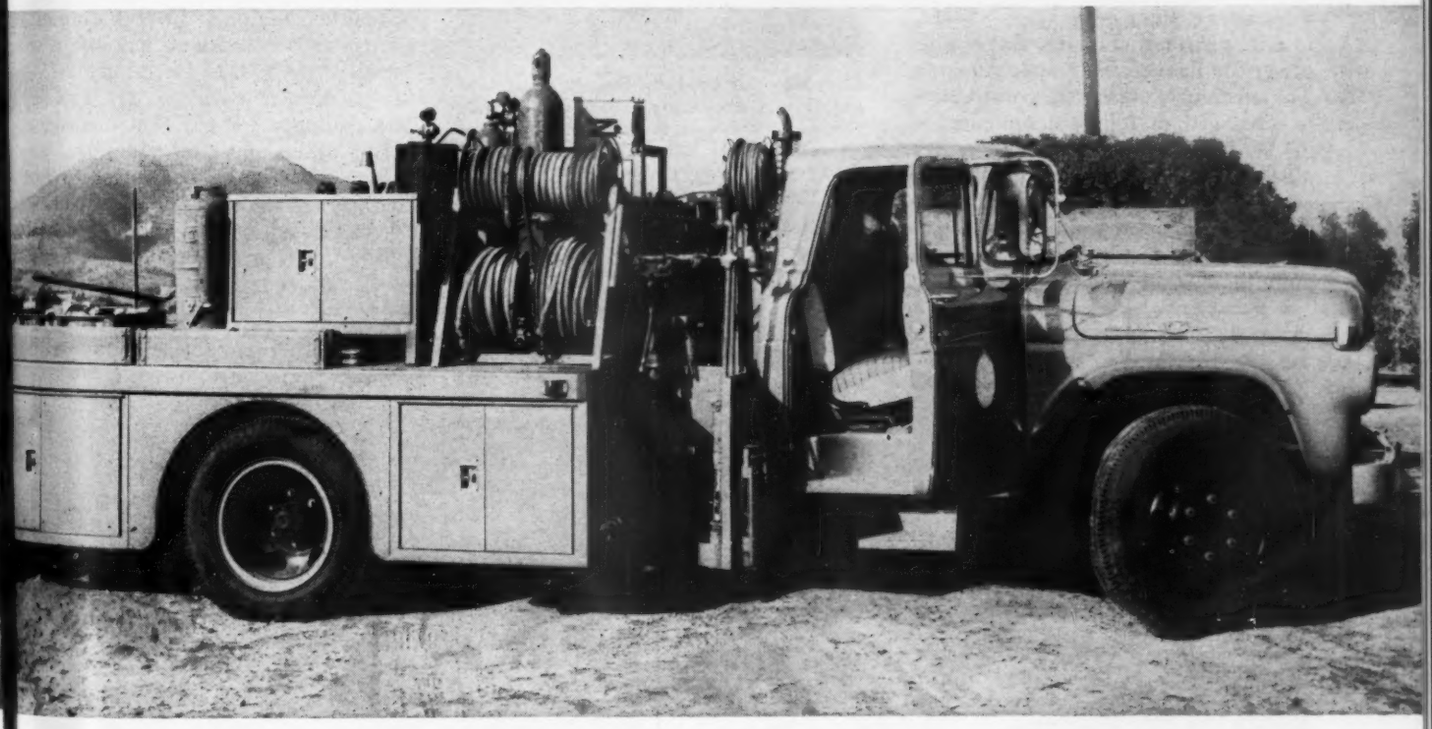
Smaller, Less Expensive—These utilities were first attracted to the Rotary PTO Compressor because of several outstanding advantages. One, it is compact—takes up 50% less space than conventional self-contained units. Two, it is less expensive. And, three it is extremely light in weight.

You can gain some idea of its compactness from the following specifications: 31½" high, 39¼" wide, 28" long —*about the size of a desk*. The unit weighs 850 lbs. versus 2400 lbs. for conventional equipment. More of your truck can be devoted to other essential equipment. Mounting is simple, too. The two-stage oil-cooled compressor, oil cooler, air receiver, oil separator and oil storage receiver gauge panel are all mounted on one fabricated steel base plate.



Midwest Utility* BOUGHT 1—RE-ORDERED 7 MORE

↓ West Coast Utility* BOUGHT 1—RE-ORDERED 9 MORE



IF THESE UTILITIES RE-ORDER

Produces More Air—Your operator can handle the Rotary Power Take-Off Compressor right from the truck cab. Since it's a rotary, with infinitely variable capacity control, it will produce more air than reciprocating units. And by eliminating the engine, of course, you reduce maintenance work.

Why don't you try out the Rotary Power Take-Off idea in your fleet. Just add one unit and, take it from us, you'll be back for more. Worthington Corporation, Holyoke, Massachusetts.

*Names on Request

WORTHINGTON CORPORATION
Section 60-20
Holyoke, Mass.

Please send me a copy of Bulletin 6053-E2 describing your Rotary Power Take-Off Compressor.

WORTHINGTON

Name_____

Company_____

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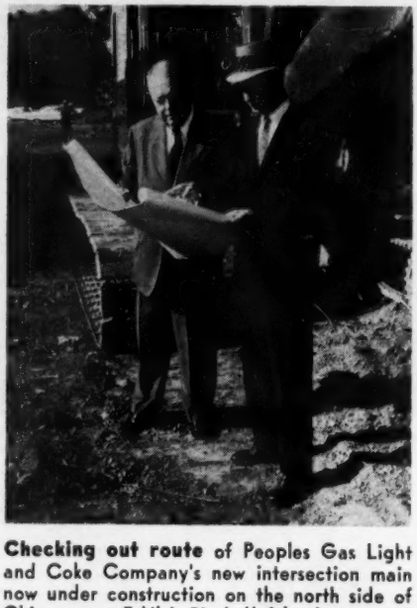
City_____ **State**_____

Distribution Developments

Saskatchewan Power Corporation, Regina, Saskatchewan, Canada, has completed distribution system gas mains in 10 of the 22 communities included in its $10,000,000 1960 gas construction program. The 10 completed are Fort Qu'Appelle, Elrose, Kyle, Burstall, Balcarres, Smiley, Kamsack, Qu'Appelle, Canora and Tompkins. Centers remaining are Wolseley, Grenfell, Indian Head, Broadview, Pense, Riceton, Lang, Midale, Stoughton, Nipawin, Carrot River and Assiniboia. Banister Construction Company, Ltd. of Edmonton expects to complete distribution systems in Nipawin and Carrot River by August. Construction is underway at Indian Head. Following completion of the system, crews will move on to Wolseley to install 8½ miles of 4-in. lateral supply line, 6 miles of 2 to 6-in. distribution mains, and 4 miles of service lines to serve approximately 215 customers. Grenfell construction is scheduled to follow completion of the Wolseley line. Project involves 8½ miles of 2-in. lateral supply line to connect Grenfell with Trans-Canada transmission lines; approximately 6½ miles of 2 to 6-in. distribution mains, and more than 5 miles of services to serve 320 customers this year. F. E. Shaw Ltd., Calgary, Alberta, has been awarded the construction contract for natural gas distribution systems, in Assiniboia, Ormiston, and Claybank at an approximate cost of $80,000.

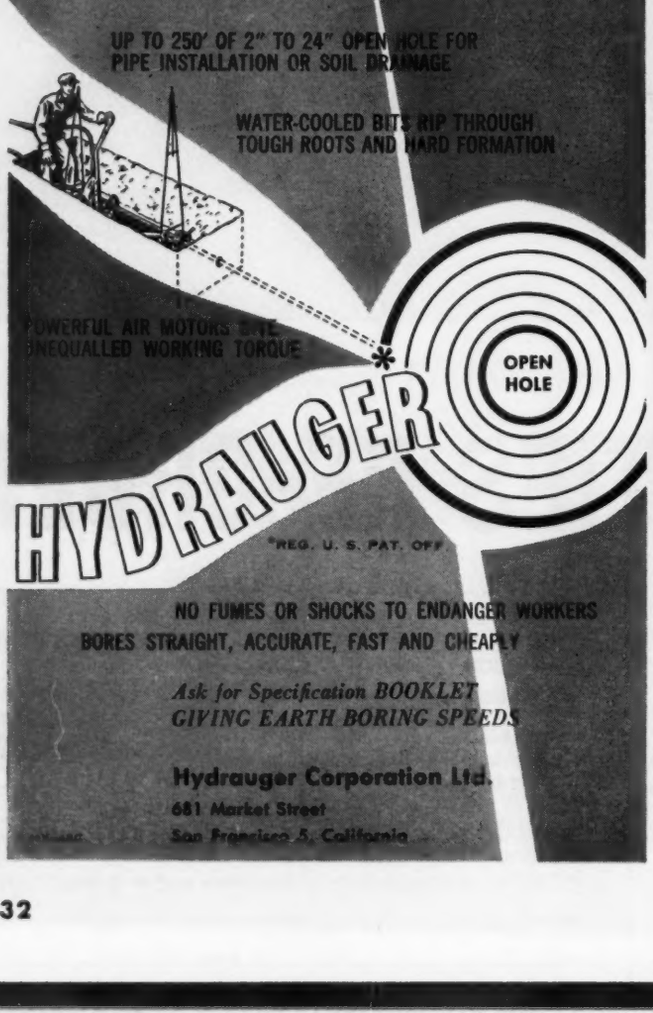


Checking out route of Peoples Gas Light and Coke Company's new intersection main now under construction on the north side of Chicago are Eskil I. Bjork (left), chairman of the board, and Emory A. Manlove, vice president in charge of operation.

Public Utilities Company, Crossett, Arkansas, has construction underway on 30,000 ft of ¾ to 3-in. gas distribution lines in the city of Shuqualak, Mississippi, and 60,000 ft of 1 to 4-in. gas distribution lines in the city of Fayette, Mississippi. Eubanks & Smith Pipeline Construction Co. of Greenville Mississippi, is the contractor.

Iowa Electric Light & Power Company, Cedar Rapids, Iowa, plans to spend $205,960 to extend and convert its manufactured gas distribution system in Chariton, Iowa, anticipating FPC approval of Lateral Gas Pipeline Company's petition to build a $298,471, 17-mile, 6-in. line from Natural Gas Pipeline Company's main transmission line south to the city of Chariton. Iowa Electric's distribution project involves 12,600 ft of 4-in. and 15,000 ft of 2-in. Other construction projects underway are gas main extensions in Sibley, George, and Ashton, Iowa.

Stoughton Light & Fuel Company, Stoughton, Wisconsin, has been ordered by the PSC to extend natural gas service to a new school. The building was equipped for gas heat in original specifications and after equipment was installed, the school board was advised that gas service would not be available. A school board delegation asked the PSC to help in the problem, with the service order resulting.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UP TO 250' OF 2" TO 24" OPEN HOLE FOR PIPE INSTALLATION OR SOIL DRAINAGE
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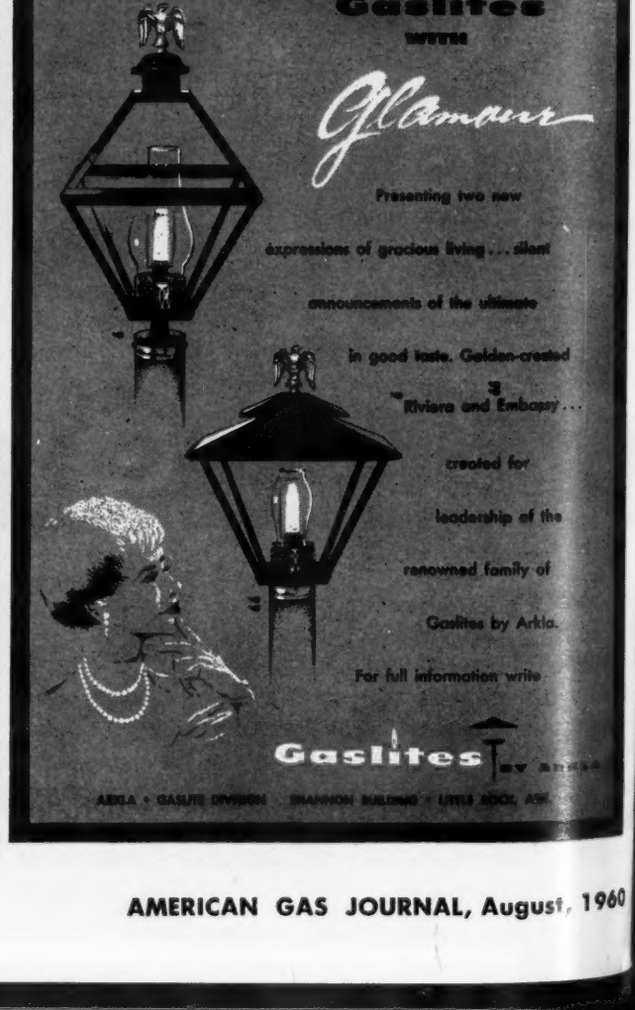
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COOKING IN THE FIREPLACE was romantic but hardly efficient. Heat was slow, uneven, uncontrollable . . . iron pots and pans, heavy. Feeding the family was work!

BASIC . . . but better than ever today

GAS "BURNERS WITH BRAINS" in today's kitchen . . . most recent achievement of the gas industry . . . "feel" and control heat in pots and pans . . . make cooking automatic . . . a pleasure!

Throughout the nation the cast iron gas mains of 55 major utilities are still serving after over a century of profitable operation. Cast iron pipe's quality is no accident. In our case, we assure it by controlling every production step. From mine to finished product, every length of pipe is subjected to exacting tests. This added care along our line contributes to smooth, trouble-free performance in yours.
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- Standardized mechanical joints are bottle-tight for usual gas distribution pressures . . . and for all types of gas.
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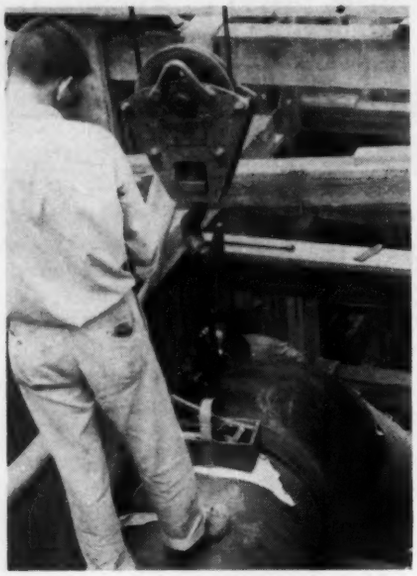
Distribution Developments



Twisting down and under the BMT at Avenue S and West Sixth Street, Brooklyn Union's Jamaica Bay line detours briefly to dip 20 ft under a 12 by 12 ft sewer in crowded metropolitan New York. (Other construction pictures on page 29.)

Wisconsin Public Service Corporation, Milwaukee, Wisconsin, plans to spend $276,165 to bring natural gas service to Oconto, where it now serves the community with electricity. Company also has received Public Service Commission authority to convert from manufactured to natural gas at Marinette, Peshtigo, and Stevens Point, and introduce natural gas at Whiting and Park Ridge.

Wisconsin Power and Light Company, Madison, Wisconsin, has PSC okay to spend $93,000 to construct a natural gas system at Oakfield. It will be supplied from the Waupun-Fond du Lac pipeline. Construction also is under way to transmit natural gas from the Beloit gate station to the Black Hawk steam generating plant where gas will be used in one boiler unit.

Northern Natural Gas Company, Omaha, Nebraska, plans to extend natural gas service this year to 58 new communities in Iowa, Minnesota, and Wisconsin. The 58 communities are part of the 342 towns Northern was authorized to serve by a FPC decision last year; 43 of the communities were added to the system in 1959. The 1960 construction program includes 35 communities in Iowa, 19 in Minnesota, and 4 in Wisconsin. They are: In Iowa — Ashton, Badger, Delhi, Denison, Dexter, Dysart, Earlham, Earlville, Elk Run Heights, Epworth, Evansdale, Farley, Garrison, Garwin, George, Gilbertville, Gladbrook, Goldfield, Hazelton, Jamaica, Janesville, Jesup, La Porte City, Maquoketa, Nora Springs, Oelwein, Raymond, Sibley, Stuart, Tama, Toledo, Traer, Vinton, Washburn and Wellsburg. In Minnesota—Cambridge, Coates, Crosby, Deerwood, Glencoe, Goodview, Hutchison, Ironton, La Crescent, Lakeville Township, Litchfield, Little Falls, Princeton, Prior Lake, Sartell, Twin Lakes, Waconia, Willmar and Winona. In Wisconsin—La Crosse, French Island, Onalaska and Shelby. The construction program involves 530 miles of branch lines ranging from 2 to 16-in. pipe. In Iowa project involves installation of 114 miles of 2 to 12-in. line by Prairie Construction Co., Lubbock, Texas; 89.4 miles of 2 to 6-in. by R. E. Reutzel Co., Fremont, Nebraska, and 26 town border stations by Panama Williams Corp., contractor; 28.4 miles of 3 to 6-in. and three town border stations by Underground Constructors, Dodge Center, Minnesota. In Wisconsin and Minnesota, 133.5 miles of 2 to 16-in. pipe and four town border stations will be installed by C. S. LeNoir Co., Austin, Texas. In Minnesota, 162.9 miles of 3 to 24-in. line will be installed by Pipeline Welding Co., Tulsa, Oklahoma; and 14 town border stations, by Panama Williams Corp.

Milwaukee Gas Light Company, Milwaukee, Wisconsin, has applied to the PSC for authority to substitute natural for butane air gas at Waupaca and Marshfield. Williams Bros. of Tulsa, Oklahoma, contractors, have an undetermined amount of city distribution work in the city of Marshfield, Wisconsin.

Also, MGL has asked for PSC permission to purchase Winnebago Natural Gas Corp. of Kaukauna, Wisconsin, for $2,517,500. Winnebago currently operates in Kaukauna, Kimberly, Little Chute, and has PSC permission to start service in 15 other communities. In addition, it has franchises, currently undeveloped, to distribute natural gas in 27 other communities.

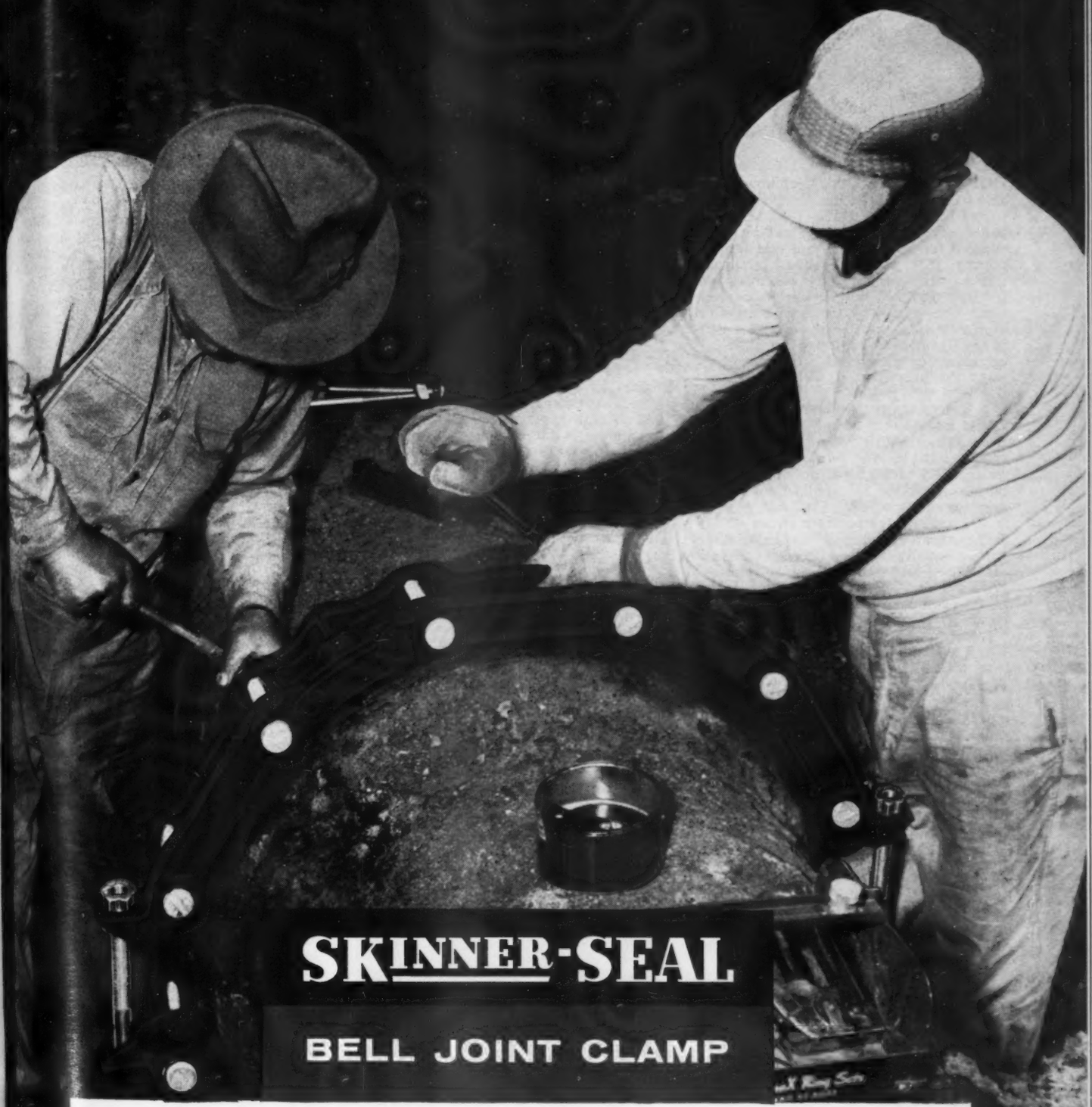
Wisconsin Fuel and Light Company, Manitowoc, Wisconsin, has applied for PSC permission to initiate natural gas service in Mosinee and the town of Kronenwetter. Gas will be available to these communities from an 8-in. line tapping a 22-in. transmission line about 10 miles north of Stevens Point.

Wisconsin Michigan Power Company, Appleton, Wisconsin, has PSC okay to spend $90,000 for installation of 6500 ft of 10-in. gas main in Neenah. Anticipated volumes of gas in 60-61 would exceed present capacity of 4- and 6-in. mains now in use.

Springfield Gas Light Company, Springfield, Massachusetts, has extended its gas mains to serve a state-aided low cost housing development of 150 units in Chicopee where gas will be used for heating, cooking, and water heating. First public school in Massachusetts to be gas heated is scheduled for occupancy this fall. Individual heating units are to be used in the classrooms of the East Street School in Ludlow. Company has installed propane storage tanks at its auxiliary gas manufacturing plant, under construction in West Springfield. Completion date is set for early fall.

Despite water obstacles, small crew laid several hundred ft of pipe daily during construction of 18-in. supply line for Northern Indiana Public Service Company that will bring natural gas to Indiana communities of North Judson, Medaryville, Francesville, Monon, Monticello, Fowler and Kentland.

CLAMPING BELL JOINT LEAKS



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M. B. SKINNER CO., SOUTH BEND 21, INDIANA

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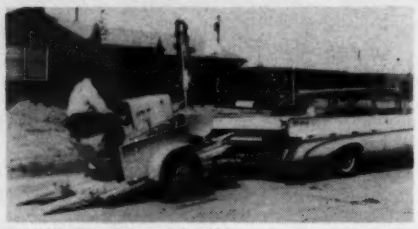
MATERIALS – EQUIPMENT – SERVICES



Utility Trailer with tilting deck now available from Davis Mfg. Inc. is especially designed to carry the Davis T-66 Self-Propelled Trencher. Trailer unit is also adapted for a wide variety of other transporting jobs. Special ribbed channel tracks with locking ends are available for hauling the T-66; 10½-in. high steel removable sides with tie-down bolts also available. Unit pulls easily behind a car, is readily maneuverable for safe, pulling on residential streets and into home driveways. Features all-steel, welded construction.

CIRCLE (1) ON THE REPLY CARD

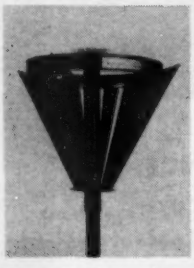
Latest addition of 3 and 4-in. air pipe sizes allows North American to offer a range of 1½ to 4-in. sizes in its series XSA sealed-in nozzle mixing burners. Suitable for applications where large amounts of excess air are used to secure uniform temperature (from 400 to 900 percent and higher on gas). Unit works equally well at normal air-fuel ratio or at rich ratios up to 50 percent, provided the additional air needed for nearly complete combustion is in the combustion chamber. With 16 osi air pressure, range of 354,000 to 3,250,000 Btu is available in the 6 straight gas sizes.

CIRCLE (2) ON THE REPLY CARD

Portable repair kit, designed for simple, economic, and rapid permanent repairs to pipe and tubing, pipe joints, fittings, and tanks and other vessels is now available from Dresser Manufacturing Division. Designated the "Util-Seal" Kit, the new epoxy resin utility repair kit doubles as a carrying case, and is small enough to be carried as space gear on all service trucks. Leaking bell and spigot joints, flanges, saddles and caulked sleeves can be quickly repaired by ordinary labor. Package has been so sized as to eliminate guesswork in combining the correct proportions; contains individual portions of resin, activator and fibrous reinforcer, as well as a collector ring and pressure relief vents for use during the "setting-up" period.

CIRCLE (3) ON THE REPLY CARD

Arkla has added three new gas light designs to its line, including a unique gas torch, called the "Waikiki." An entirely new type of gas-flame illumination, the new gas torch has a stainless steel flame-spreader designed for uniform flow at every circumference point, heavy steel construction, and a weatherproof classic black finish. Overall dimensions are 11 by 15½ inches. Other two models are the *Homesteader* and a budget-priced *Phoenix* designed primarily for multiple "Gaslite" installations such as in home subdivision, shopping centers, motels and similar commercial applications.



CIRCLE (4) ON THE REPLY CARD

New series of digital transducers to measure pressure, flow, temperature, or other variables has been designed to provide greatest possible reliability of operation and ease of maintenance. Units provide a digital output in the form of contact closures for data recording or transmission. Standard components are available for incorporating series into a data recording or transmission system. Units may be equipped with a deviation or upset alarm detector to alert the operator in the event that the measured variable deviates from its normal or previous magnitude. General bulletin on Datex Corporation's entire series of digital transducers is available.

CIRCLE (5) ON THE REPLY CARD

Utilization. New furnace pressure transmitter, recently announced by GPE Controls, Inc. of Chicago, converts low pressures to a high-level electrical signal, designed for open hearth furnaces, soaking pits, slab heating furnaces, glass tanks, and similar applications. Output of the transmitter is a direct-current voltage signal in the range of 0-25 v d-c, a signal great enough to be used directly and simultaneously by standard d-c recorders and indicators, analog-to-digital converters, and electrohydraulic valve actuators.

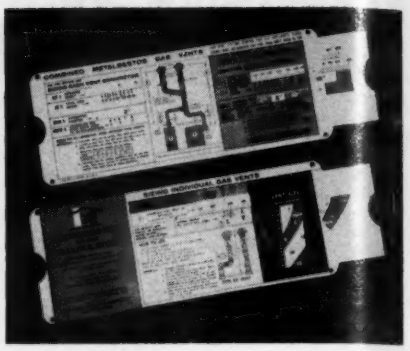
CIRCLE (6) ON THE REPLY CARD

Compact, lightweight pressure regulators designed to handle broad range of pressure are now available from Grove Valve and Regulator Co. New regulators, called Mity-Mite, may be used for pressure reducing, back pressure, and combination pressure reducing and relief service. Pressure reducing models, in sizes from ¼ through ½-in., can be used for inlet pressures as high as 10,000 psi and adjustable controlled pressures up to 6,000 psi. Combination pressure reducing and relief regulators in sizes ¼ through 1-in., are designed for inlet pressures up to 6,000 psi. Back pressure models will accommodate pressures up to 3,000 psi and are available in ¼-in. sizes.

CIRCLE (7) ON THE REPLY CARD

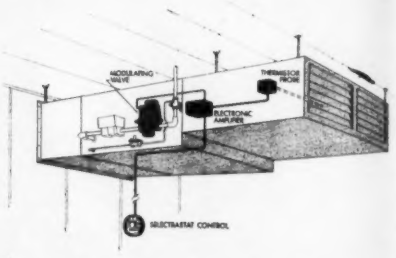
New transistorized 2-way radio is now available in units up to 100 watts, in low band frequencies, 25 to 50 mc. Unit is packaged in a case as small as 4-in. high, 8⅝ in. wide and 15-in. long. May be mounted under the dash in most cars and trucks; however, the unit is designed in two sections to facilitate mounting in trucks, under seats, and in various other parts of the vehicle. Power drain on the battery when unit is on standby (ready to receive a message) is only 40 milliamperes using a 2-watt speaker; this enables a driver to turn his vehicle's engine off and still hear his radio without worrying about possible battery problems.

CIRCLE (8) ON THE REPLY CARD



Gas Vent Calculator. Newest aid in determining safe, accurate gas venting has been developed by Metalbestos Division of the William Wallace Co. Called a Gas Vent Calculator it fits in a shirt pocket, works out correct gas vent pipe sizes in seconds for any gas-fired appliance installation. It simplifies the designing and installing of these systems. User only has to know the rated input of the gas appliance to be installed or in service, the lengths of the lateral and vertical runs, and the number of customers in the system. The slide rule calculator does the rest and shows the correct vent pipe sizes.

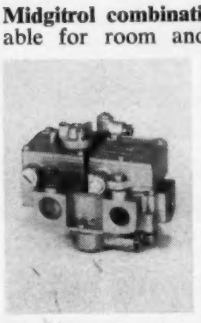
CIRCLE (9) ON THE REPLY CARD



Electronic modulation system for gas-fired duct heaters used in make-up air systems has been announced by Maxitrol Co. New system eliminates many of the problems of introducing comfortable make-up air into public halls, theaters, restaurants, etc. To overcome the general tendency to overheat make-up air in mild weather, Maxitrol uses a modification of the Selectra electronic modulation system introduced last year for domestic gas furnaces. The new control has a small probe that is inserted in the warm air duct between the heat exchanger and the discharge head; a sensitive temperature setting control, called a Selectrastat, may be located at any remote spot up to several hundred feet away from the heater.

CIRCLE (10) ON THE REPLY CARD

Midgitrol combination valves now available for room and wall heaters, floor furnaces, appliances and other gas-fired home equipment, are basically 4 valves in one compact body—a mainline gas cock, mainline automatic valve, pilot line shutoff valve, and mainline manual reset, 100 percent safety shutoff valve. Compact and versatile, the new General Controls' units have only 3 connections to be made by the manufacturer or installer. Piping is reduced to a minimum; and the wiring has been simplified for easy installation.



CIRCLE (11) ON THE REPLY CARD

Small leaks of any compressed gas are easier to locate with Calgon Gas Leak Detector, a high-viscosity liquid that forms bubbles when daubed on pipe joints where leakage is suspected. Leaving no deposit, harmless to skin, and non-staining, the liquid can be used with safety and without danger of fire. The new gas detector is non-freezing; functions efficiently with any compressed gas—including air, CO_2, nitrogen, natural gas and all refrigerant gases.

CIRCLE (12) ON THE REPLY CARD

Latest addition of suspended gas-fired unit heaters to Peerless Manufacturing Division's present line, makes the line complete in both propeller fan and blower models from 25,000 Btu through 300,000 Btu's. New unit heater line ranges in size from 175,000 to 300,000 Btu's. All heaters are available in either aluminized steel or stainless steel heat exchangers.

CIRCLE (13) ON THE REPLY CARD

Wheel tractor with new 57 hp (gasoline or diesel) engine designed primarily for use as a 2500 lb capacity loader and 3000 lb capacity backhoe, can also be used with a wide choice of interchangeable equipment, including crane boom, dozer, all-purpose blade, log and pallet forms, scarifier-scraper, post hole digger and cutter-bar or rotary mowers. New backhoe digs to a depth of 14 ft, reaches 20 ft from front axle; features foot-operated 180 swing and double acting swing cylinders that allow swinging boom at full speed with a cushioning effect at the end of the stroke.

CIRCLE (14) ON THE REPLY CARD

NEW SERIES of break-resistant blades for use on all masonry materials has been introduced by the Clipper Manufacturing Co. Known as the Blue Bond series, the new blades use leno-weave fiber glass reinforcing. Layers of this tough, flexible glass cloth are scientifically woven into each blade. The silicon carbide particles flow through the reinforcing mesh, protruding beyond its surface. This protects the fiber glass cloth from becoming thin from side wear.

CIRCLE (15) ON THE REPLY CARD

HAND PORTABLE EXTINGUISHERS, stationary fire equipment, piped systems, and large capacity mobile equipment such as fire jeeps and trucks are described in Ansul Chemical Company's 1960 catalog. Hand portable extinguishers shown in the catalog cover requirements for Class A, B, and C fires as well as combustible metal fires. Among the new portable units described are Ansul's Monitor extinguisher which is the only extinguisher having a factory filled recharge shell listed by Underwriters' Laboratories, and Ansul's Sentry "Energized" series which although constructed on the stored pressure principle, differs significantly in design from conventional stored pressure extinguishers particularly in the one-hand operation feature.

CIRCLE (16) ON THE REPLY CARD

Butterfly Valves of the resilient seated type for applications where positive tight closure is required are described in new 4-page bulletin available from W. S. Rockwell Co. Narrow "wafer" body of the valve and the absence of a large bonnet as on a gate valve make these butterfly valves much smaller and lighter. Available in sizes from 2 to 36-in.

CIRCLE (17) ON THE REPLY CARD

BUYERS GUIDE for valve specifiers, users, and purchasers. Ohio Injector Co. has designed a brochure that cross indexes the complete OIC line with valves of 16 major manufacturers. Guide also contains a list of frequently used abbreviations, a valve trim chart, a list of valves conforming to federal specifications, and complete figure number descriptions. Breakdown of OIC valves by valve material and pressure class, and classification by type, disc design, seating arrangement, stem operation, bonnet, and end connection serves as an additional guide to proper valve selection.

CIRCLE (18) ON THE REPLY CARD

Pipe beveling machine storage boxes, manufactured by H & M Pipe Beveling Machine Co., are now being built of aluminum instead of steel, thereby reducing weight of boxes by approximately two-thirds. New boxes provide same strength and protection with added advantage of requiring no painting and being in no danger of rusting. Are available in 7 different sizes to hold every model H&M pipe cutting and beveling machine.

CIRCLE (19) ON THE REPLY CARD

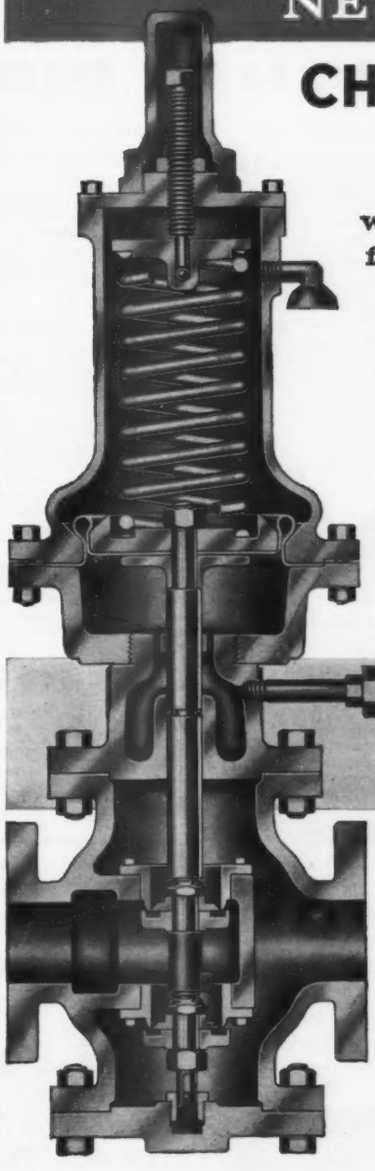
NEW IN PRINCIPLE!
NEW IN DESIGN!

CHAPLIN-FULTON

Model 57-S

GAS REGULATOR

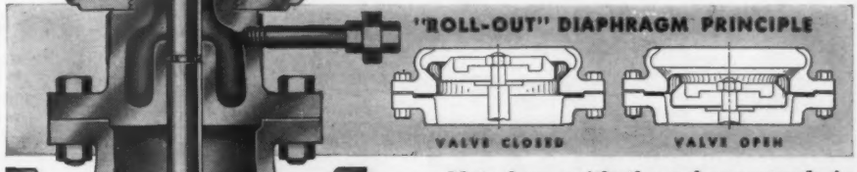
with "ROLL-OUT" Diaphragm for constant pressure control



Chaplin-Fulton Model 57-S is a simple spring loaded regulator which performs like a pilot loaded regulator, without the added complications. For pounds-to-pounds service—inlet pressures to 400 psi—controlled pressures to 75 psi, with deviation through full valve travel less than 1 psi.

NO "FALL-OFF" AS FLOW INCREASES

The drooping characteristics or outlet pressure "fall-off," typical of conventional spring regulators, is eliminated—not by using an uncontrollable velocity effect—but by a new diaphragm design which actually reverses the action of a conventional diaphragm. It changes its area as the valve opens to compensate for the loss in spring loading force.



Note how, with the valve upwards in the closed position, the diaphragm achieves its maximum effective area—and decreases as the valve opens. The area changes at the same rate as the spring loses compression, to give a constant controlled pressure—determined entirely by valve movement.

2" - 3" - 4" - 6"
Write for Bulletin 57-S

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Chaplin-Fulton

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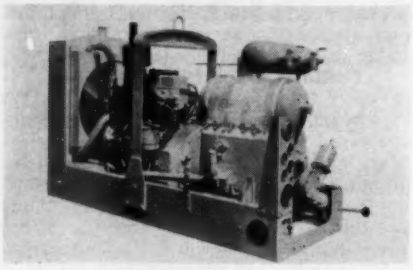

An improved 125 cfm rotary compressor for cross mounting behind cabs on motor trucks, recently announced by Davey Compressor Co., is said to be dimensionally smaller, more compact and lighter than other machines for across-truck use. Features include curbside location of all controls, gages, service outlets, and vertical instrument panel. Compressor unit is of the Hydrovane rotary type; accessories, such as oil filler spout, etc. are so arranged that the entire assembly can be serviced without climbing on the truck body.

CIRCLE (20) ON THE REPLY CARD

NEW CONDENSED BUTTERFLY VALVE BULLETIN — 4-pages — describes Continental's complete line of butterfly valves. Eight designs are presented in tabular form making comparison and selection easy. Valve sizes range from 1 to 108-in. with pressure drops up to 1200 psi and temperatures up to 2000 F.

CIRCLE (21) ON THE REPLY CARD

COMPLETE DETAILS ON THE SERVO-GAUGE METERING PUMP are available in a new bulletin from Associated Control Equipment, Inc. Operating principles of the pump and its controller, which has a pump-plunger-positioning accuracy within 0.002 in. repeatedly, are described. Also included are 5 typical applications. Design data listed include maximum capacity, operating characteristics, stroking rate, materials of construction, and actuating power requirements. Unit has no electrical connections, is explosion proof and because operating power can be either air or gas it is easily adaptable to isolated plants or gas lines as well as centralized process control systems.

CIRCLE (22) ON THE REPLY CARD

Pipe Threading Machines and how they work are the subject of new 16 mm sound, color movie now available from Oster Manufacturing Co. Titled, "Silver Threads Amass the Gold," the film features the larger, production, semi-production, and maintenance type threading machines, and shows correct operation of them for best performance. Of interest to anyone having to do with threading of pipe, bolts, rods, and conduit. Available at no cost; bookings made on a first-come basis.

CIRCLE (23) ON THE REPLY CARD

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